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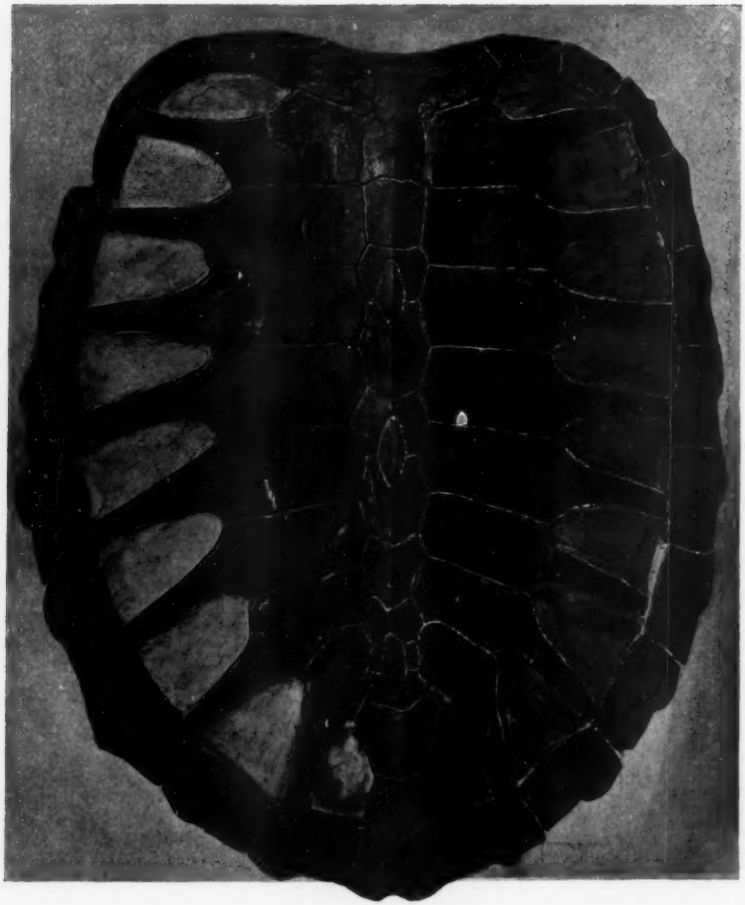

Carapace of *Toxochelys Bauri* Wieland sp. nov. from the Niobrara Cretaceous of Gove County, Kansas, as partly restored and mounted in the Yale Museum.—Actual length about 53^{cm}.

THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

Art. XXXVI.—*A New Niobrara Toxochelys*;* by G. R. Wieland. (With Plate X.)

None of the numerous marine, or semi-marine turtles from the Kansas chalk or Niobrara Cretaceous have proven of greater interest than the forms included within the genus *Toxochelys*. For this wholly extinct American group unites carapacial and plastral characters of the *Lytolomas* of the Upper Cretaceous of New Jersey with *Chelydra*-like cranial features, and is well represented by a considerable number of specific forms and variations presenting fairly clear evidence that we have here to deal with a line which independently acquired the modifications of limb structure suiting at least some of its members to a marine habitat.

Moreover it is very significant that discrete epi-neural ossicles somewhat similar to those the writer supposed might be present in *Archelon* are borne serially either on the neuralia, or over the neural junctions in an order suggesting that they have an ancient history, possibly analogous to the ossicles of somewhat similar form so characteristic of the Crocodilidæ and in part the Chelydridæ. These ossicles as noted further on were first observed in *Toxochelys* (*serrifer*) *stenoporis* by Case (2) and later more fully described and commented on by Hay (6, 7, 8). The character of the entire series is, however, now determined for the first time. The idea that such ossi-

* The writer's previous contributions, mainly on the marine turtles, are as follows:—

This Journal, vol. ii, Dec., 1896, pp. 399–412, pl. VI. American Naturalist (p. 446), 1897. This Journal, vol. v, Jan., 1898, pp. 15–20, pl. II; vol. ix, Apr., 1900, pp. 237–251, pl. II; vol. ix, June, 1900, pp. 413–424; vol. xiv, Aug., 1902, pp. 95–108; vol. xv, March, 1903, pp. 211–216; vol. xvii, Feb., 1904, pp. 112–132, pls. I–IX; vol. xviii, Sept., 1904, pp. 183–196, pls. V–VIII.—(In Press,—Protostega; Memoirs, Carnegie Museum of Pittsburgh; Plastron of Protosteginæ.)

cles really represent a disappearing series of dermal elements is further strengthened by the writer's observation that interpolated ossicles also occur in the marginal series of occasional specimens of *Lytoloma angusta*, as will be further considered below.

Despite the frequent occurrence of Toxochelyds in the Niobrara, until now no complete carapace has been described. It is, therefore, of timely interest that a specimen collected by Mr. Charles H. Sternberg in Gove County, Kansas, and very recently acquired by the Yale Museum, includes a carapace and plastron sufficiently complete to determine accurately all the details of shell structure and form. The original locality, according to Mr. Sternberg, is in a ravine about three miles north of Monument Rocks, and about four miles east of the western Gove County line. This fossil is numbered 2823 in the Yale Museum accession list, and on the basis of the analysis given below is referred to the new species *Toxochelys Bauri*, in honor of that distinguished student of the Testudinata the late lamented Professor Georg Baur. As shown on Plate X, *T. Bauri*, represents one of the most ornate of all extinct Testudinate species. The type consists in the following elements:—

The nuchal and eight closely articulated neuralia with the ninth median or post-neural element bipartite, and followed by an antero-pygal and the pygal marginal (the postero-pygal being the only median element absent); three epi-neural ossicles respectively seated on the 3d and 4th, the 5th and 6th, and the 8th–10th members of the neural series; the 1st–3d, and the 8th–11th right marginals; the 4th–6th, 8th and 10th left marginals; most of the pleuralia; also the right hyo- and hypoplastron nearly complete, and various fragments of vertebræ with several centra and arches. Of the right pleuralia the first and seventh are complete, and the third, fourth and sixth only lack rib-tips, while the expanded plates of all the right pleurals but the distal portion of the fifth, are fortunately present. On the left side the pleurals are not so complete, only the proximal ends having been recovered, with the exception of the third, which only lacks a middle portion of the plate. Cf. figure 6.

The hyo- and hypoplastron lack their interior digitations, but fortunately permit an approximate restoration from what is known of the plastron of several other species (cf. figure 7). The fragmentary or not directly determinable skeletal parts include two dorsal centra, 4^{cm} in length, and several caudal centra, with a few portions of cervicals.

With the exception of some of the middle and anterior marginals, which are curiously crushed from very different

angles, the various elements of the present in reality exceptionally fine fossil do not appear to have been much displaced in their original chalk matrix. This had been removed, however, and aside from the neurals, which remained for the greater part solidly articulated, any clues to form and organization afforded by position in the matrix had been thus destroyed before the specimen reached the Yale Museum.

Despite this crushing and dissociation of parts, as the result of a careful joint examination by the Museum preparateur, Mr. Gibb, and the writer, it has nevertheless proven possible for the former to make a very handsome and successful mounting of the fine carapace with the considerably restored plastron in its approximately natural position, as illustrated on Plate X, and figures 1–3, and 6, 7. In fact it is owing to the presence of the nearly complete hyo- and hypoplastron that we are enabled to determine the true width of the carapace, which is indicated in the corrected drawing (figure 1) based in part on the measurement thus obtained. The specimen itself is mounted more nearly as removed from the chalk matrix, the width being somewhat exaggerated by compression. For it was at once decided that it would be far better in mounting the specimen to adhere nearly to the form that had resulted from crushing in the matrix, rather than to distort the junctions of the several elements in an effort to reach the elongate form *Toxochelys Bauri* really had. The restoration is accordingly, although at first sight indicating a considerable length of shell, not nearly so narrow and relatively long as originally in life,—an interesting fact because this is almost the only marine form with a carapace suggestive of the great length seen in *Dermochelys*.

Description of Parts.

As the main features of the anatomy of the carapace appear in sufficient detail in the summary of characters and measurements given below, taken in conjunction with the accompanying figures and plates, we may pass on to a discussion of the special or unique features of interest, namely the *nuchal*, the *epi-neural spines*, and the *pygal region*.

Nuchal.—The Trionychid-like fontanelles at the junction of the nuchal, first neural and pleurals (figure 1, *f*), are circular to slightly elliptical, and 1^{cm} in diameter. Such have not been hitherto observed to occur outside the Trionychids, and with the general form of the nuchal suggest a certain connection with original lines less distant from the Trionychid stocks than are the Cheloninæ. Elsewhere the writer has suggested that the Nuchal and Epiplastra of *Dermochelys*, *Protostega*, and the *Jurassic* Thalassemyds may go to indicate a yet

closer relationship to stocks ancestral to the Trionychidæ, and that there are many most suggestive indications that indepen-

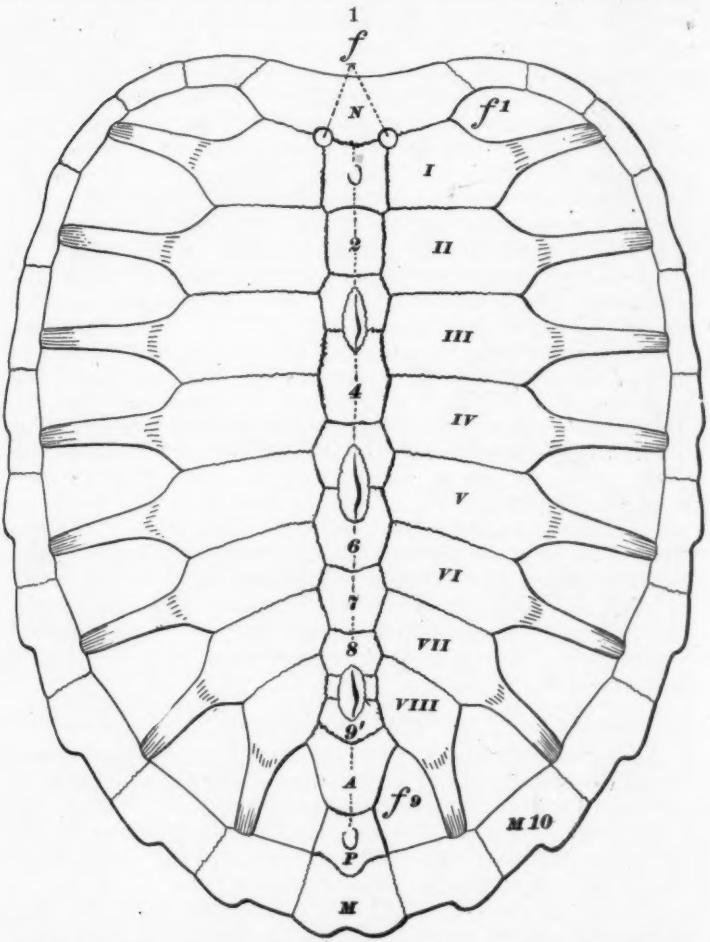

FIGURE 1.—Carapace of *Toxochelys Bauri* Wieland, $\times \frac{1}{4}$ nearly. (Drawn from type.) *N*, Nuchal; 2, 4, 6, 8, Neuralia; 9′, posterior segment of the 9th or post-neural element of the median series; *A*, Antero-pygal; *P*, Postero-pygal; *M*, Marginalo-pygal; I–VIII, the Pleuralia; *M10*, 10th (rib-free) Marginal; *f*, the post-nuchal foramina; f^1, f^8, 1st and 8th pleuro-marginal fontanelles. The three Epi-neurals are not lettered.

dent marine races of Testudinates, of which at least a half dozen may be enumerated, have been repeatedly developed ever since the Jurassic.

It is also of much interest that while in forms like *Osteopygis* a nether nuchal process is wholly absent, there is in the present turtle a mere, although distinct beginning of such a

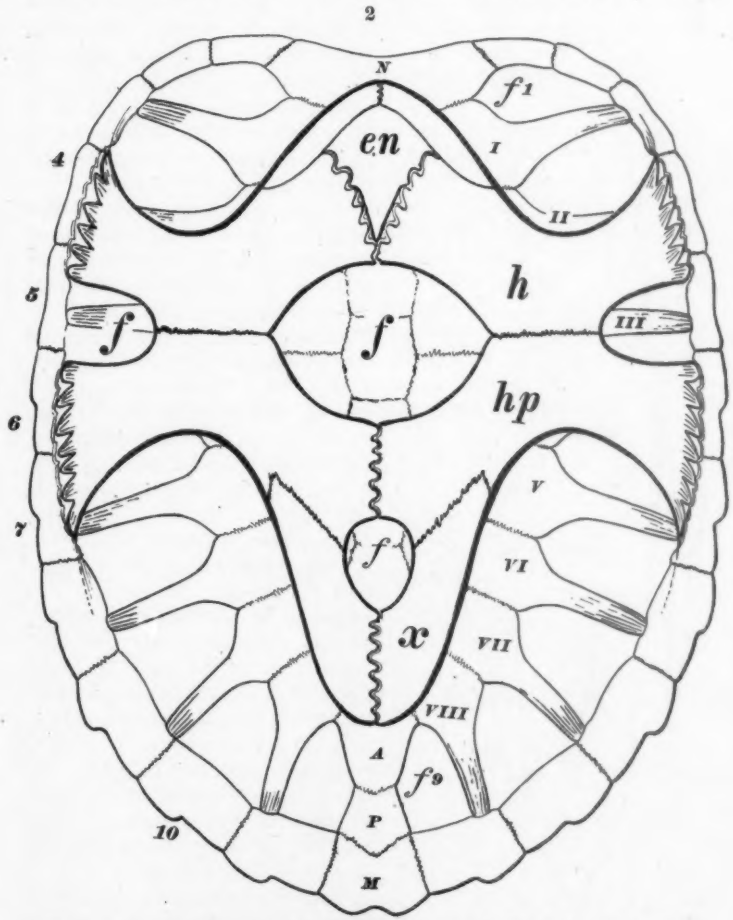

FIGURE 2.—Plastral view of *Toxochelys Bauri* Wieland, ×¼ nearly. (Drawn from type).—*en*, Entoplastron; *h*, Hyoplastron; *hp*, Hypoplastron; *x*, Xiphiplastron; *f*, *f*, *f*, the median and the lateral hyo-hypoplastral, and the hypo-xiphiplastral foramina; 4–7, the plastron-supporting marginalia. Other letters as in figure 1.

process, and in *Toxochelys latiremis* a much larger projection for actual cervical articulation. This process thus appears to have arisen in different groups rather than to have been com-

monly present in Cretaceous turtles, and may now be considered to have been definitely traced to its origin in at least one genus.

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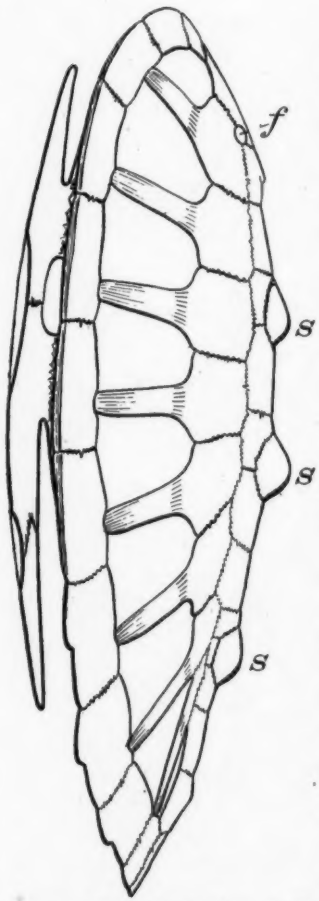

FIGURE 3.—Lateral view of the Carapace of *Toxochelys Bauri* Wieland, × ¼ nearly. Drawn from the type. *s, s, s,* the three Epi-neural spines supported respectively by the 3d and 4th, the 5th and 6th neurals, and the 8th neural and the post-neural elements; *f,* the post-nuchal foramina.

Epi-neural Spines.—The series of epi-neural spines taken in conjunction with the strongly carinate neurals, and the keeled marginals, give to the present fossil carapace a most ornate form. See figures 1 and 3.

The earliest suggestion of the possible presence of epi-neural elements in the Testudinata was made by the writer in his original description of the Fort Pierre Cretaceous turtle *Archelon* given in this Journal for Dec., 1896. It appears on page 400 of that number as follows: "One of the chief features of the carapace is the arching into a heavy dorsal ridge, beginning just back of the region of the first dorsal vertebra, and from thence continuous, except in the sacral region. It marks the position of the neural spines and is very distinctly grooved from anteriorly to the region of the eighth dorsal vertebra. Immediately over the neural spines this groove inclines to widen and send out asteriations. In life these grooves were no doubt filled with horny material, and the animal *may have borne a dorsal row of spines.*"

Two years later the spines of *Toxochelys* were first observed by Case,* and have been since more fully described and commented on by Hay, who would see in them the remnants of a former dermal series, probably once common to all turtles, and going far to explain the homol-

* Kansas Univ. Geol. Survey, vol. iv, p. 382 (1898).

ogy of the osteodermal mosaic of *Dermochelys* (6, 7). The present is, however, the first time that the entire series of ossicles and their relation to the successive neurals has been determined. As may be judged from reference to the several figures, the system of ossicles may really be a much changed and disappearing one. The first neural bears a small but very distinct completely fused boss near its middle, and then forms the beginning of the dorsal carina. The third neural which is rather short, and the fourth which is abnormally long, support a large epi-neural spine. This occupies all the median posterior three-fourths of the length of the third and the anterior fourth of the length of the fourth neurals, and is doubtless the second member of the original epi-neural series. The second free epi-neural [or third of the original series] is the largest, and is equally borne by the fifth and sixth neurals. The third free epi-neural [or fourth of the hypothetical primitive series] rests over the ninth member of the neuralia, so as to project slightly forward onto the eighth and well backward over all the anterior half of the post-neural tenth. This latter epi-neural is the smallest of the three free epi-neurals.

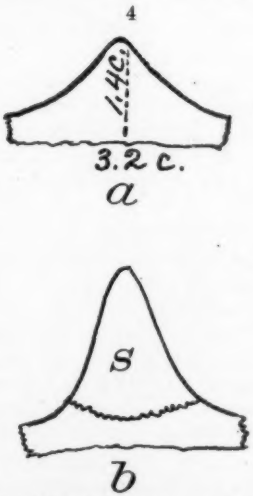

FIGURE 4.—*Toxochelys Bauri* type, $\times 1/1$. *a*, Vertical transverse section through the second neural showing the average elevation and outline of the median neural carina. *b*, Vertical transverse section through anterior end of the 6th neural, and the epi-neural spine (*s*) borne on this and the 5th neurals.

Whether a fifth member of the epi-neural series was borne by the postero-pygal, which would afford the symmetrical position, is of course conjectural in the absence of this latter member of the median series.

Whether or not the keels of the marginalia mark the fusion of a lateral series of elements, corresponding to the epi-neurals, is likewise only conjectural, although it appears that some light may be shed on the subject by *Proganochelys*. There is however some uncertainty as to the number of marginals and true significance of the peculiar marginal fringe of spines in this singularly interesting turtle as so carefully studied by Fraas (4) from material recovered under conditions unfavorable to the exact preservation of structural details. But it is also a most interesting and suggestive fact that small ossicles are irregularly interpolated between the lateral marginals of the Cretaceous *Lytoloma*, as small triangular elements about 1·5^{cm} on each side. Such are shown at E, E, E in the accompanying figure 5. As these epi-marginal ossicles are not equally present on both the right and left marginals even in the same individual and certainly not always present in all specimens of *Lytoloma angusta*, they would at first sight appear to be of much less significance, taken by themselves, than are the epi-neurals of *Toxochelys*. Nevertheless it would now seem that they do represent a disappearing series that may once have invested the entire margin of the carapace. If so, they form one of the most impressive examples of the very last vestiges of a vanishing series.

The truth of this hypothesis yet remains to be mainly determined by fossil evidence, which we may hope ere long to discover, if correct. At any rate it is extremely interesting and suggestive to find further traces of an additional osteodermal series in *Lyotoloma*, whatever may be the homology to that of *Dermochelys*.

What the characteristic number of elements in this system as developed in pre-Cretaceous testudinates was, no one has yet attempted to suggest. Nor is it possible to reach a safe conclusion in the absence of further paleontologic evidence. It would appear however that the series was once at least as complex as is the horn-shield and the bony plate series, and that it had some form of alternate or imbricate relationship to both these latter systems. Also, if the osteodermal mosaic of *Dermochelys* arose from such an additional dermal series, such origin must therefore have been in part by a subdivision process such as was suggested to Baur by the abnormal breaking up into smaller ossicles along the edges of the pleurals observed by him in *Eretmochelys*. Such a subdivision would of course follow the lines of the original system, and could thus very well produce the carapacial carina seen in *Dermochelys*.

It should be especially noted in this connection that such an hypothesis for the more primitive origin of the osteodermal mosaic does not necessarily imply a more ancient origin for

Dermochelys than for the Cheloniidæ, and that its correctness would not necessarily leave *Dermochelys* the most primitive of turtles, but rather the most specialized, as hitherto held by Baur, Dollo, and the writer. As stated, only new fossil evidence can settle the very interesting questions that here arise.

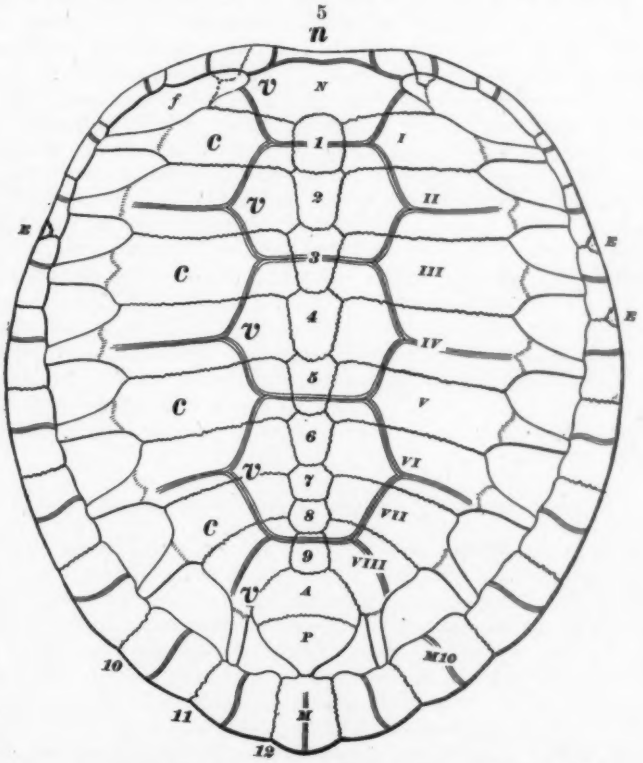

FIGURE 5.—Carapace of *Lytoloma angusta* from the Upper Cretaceous Greensand of Barnsboro, Gloucester Co., New Jersey. *E, E, E,* Epi-marginals respectively borne by the right 4th and 5th, 5th and 6th, and the left 4th and 5th marginalia. (Enough marginals are present in the original specimen—No. 625 of the Yale Collection—to determine that no further epi-marginals accompanied these three, unless such were borne anteriorly to the 4th marginals.) Epi-marginals are not always present in *L. angusta*.

The pygal region.—The neural series of *Toxochelys Bauri*, excluding of course the epi-neural ossicles, agrees with that of *Hardella thurgi* (1) in having ten elements, in the neural row, —in reality an interpolated element between the normal or

common eighth and ninth elements, or better a division of the ninth or post-neural region of the median series. Unlike *Hardella*, however, the pygal is not single, the post-neural region being divided into an antero- and postero-pygal, as in *Osteopygis*, and in the Cheloninæ. The existence and outlines of the postero-pygal are indicated by the conformation of the pleuralia and posterior marginals, together with the posterior suture of the antero-pygal and the anterior suture of the pygal marginal, which are quite unlike. From these sutural borders it is also quite evident that the heavy median keel which evenly traverses all the length of the antero-pygal, finally ran out on the postero-pygal, where it no doubt ended as a distinct boss like that of the first neural, which would perforce represent a fused fifth member of the median or epi-neural ossicular system. The pygal marginal, in correspondence with the strong keels of the marginals, is ornately double-keeled. The organization of this region has not hitherto been determined in any species of *Toxochelys*. Both Case (2) and Hay (6) have figured the posterior half of the carapace of *T.* (*serrifer*) *stenoporus* type, but without determining the sutures, whether because not indicated or because of difficulty of interpretation not being stated by either. A distinct difference from the present specimen is, however, obviously present in the postero-pygal region.

Synopsis of the Characters of Toxochelys Bauri (type).

Carapace.—Elliptical to elongate in outline with large and persistent pleuro-marginal fontanelles; composed of 52 bony plates and 3 additional epi-neural spinose ossicles; numerical arrangement of parts combining the general alignment and form seen in the Chelonine *Lytoloma angusta* with the post-neural arrangement of the existing *Hardella thurgi*. Surface finely granulate to smooth, and horn-shield sulci not apparent, save for notches formed by the posterior border of the marginal keels. (A distinctly leathery hide is not, however, supposed to be present.) Marginals, 11 pairs, rather narrow anteriorly, increasing very slowly in breadth to the 11th, which is still nearly twice as long as broad, outer borders all the way to the pygal marginal more and more sharply keeled anterior to the indistinct to absent horn-shield sulci, upper and nether surfaces of nearly equal area, supported by rib-ends only with the pits of the plastral digits small to indistinct and extending from the 3d to about the middle of the 7th; rib-pits small, with the 10th marginal ribless, and the 11th supporting the 9th rib anteriorly as in *Chelone* and *Lytoloma*.

Nuchal large and very broad, uniting by straight sutures with the 1st neural and 1st pleurals, between which are formed

posteriorly two small oval fenestrae as in the Trionychids; with a minute (incipient) nether articular projection but no costiform processes. Neuralia 8 with the post-neural bipar-

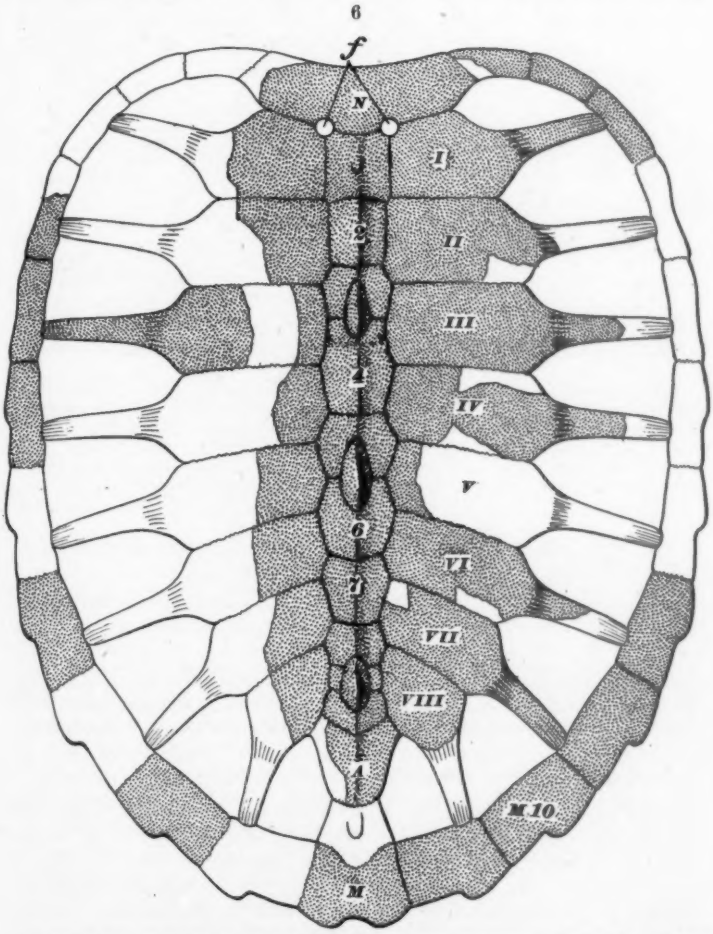

FIGURE 6.—*Toxochelys Bauri* (type). A supplementary figure to Plate X, showing by stippled surfaces the parts of the original carapace actually recovered. (Lettering as in figure 1.)

tite, oblong to hexagonal, prominently carinate and supporting the three large epi-neural spinose ossicles. Antero- and postero-pygal nearly as in *Lytoloma*. Pleuralia more reduced than in either *Chelone* or *Lytoloma*.

Plastron.—Of the same Chelydroid form seen in *Osteopygis* and *Lytoloma*.

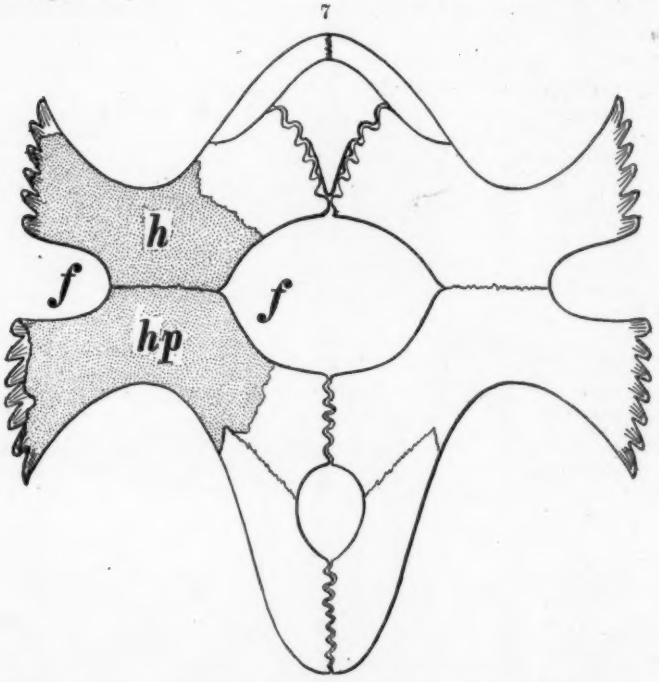

FIGURE 7.—*Toxochelys Bauri* (type). Restoration of the plastron. × ¼.—The stippled surface shows the portions of the hyoplastron (*h*) and the hypoplastron (*hp*) actually recovered.—(The epiplastron and entoplastron is only known in *T. latiremis*, cf. figure 8, and the xiphiplastron in *T. stenoporus*.)

Specific Relationships.

The specific identity of the *Toxochelys* described in the foregoing pages with any of the known species of the genus cannot be affirmed, as appears from the following analysis.—Five species have been assigned to the Niobraran genus *Toxochelys* as first established by Cope in 1873, namely: *T. latiremis*, the generic type; *T. serrifer*, Cope, 1875; *T. brachyrhinus*, Case, 1898; and *T. procax* and *T. stenoporus*, as proposed in a recent revision of the genus by Hay (8).

With *T. latiremis* as close a comparison as desirable is not yet afforded, since but few of the elements of the carapace and plastron of this form are known. It appears, however, that the nuchal was of markedly different proportions from those

of the present *T. Bauri*, as may be noted on comparison with a nuchal figured by Case.*

Nor is there specific agreement with the nuchal of the Yale specimen I referred to, *T. latiremis*, when describing the accompanying flipper (10). This nuchal is here shown in figure 8 for the sake of more convenient reference.

8

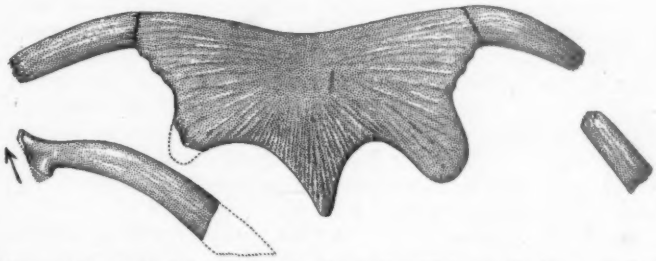

FIGURE 8.—*Toxochelys latiremis*, from the Niobrara Cretaceous, Gove County, Kansas. (Yale accession list 2419.) × about ⅓.
Nuchal with the attached first marginals of both sides and the proximal half of the right second marginal, together with the accompanying epiplastron.—This nuchal bears far back nearly in line with the front border of the large curved posterior notches a large and prominent nether process for cervical articulation.

Although true that the general form varies in turn from that just noted as figured by Case, the differences are more easily reconciled within specific limits. The simple fact is that in no previously described specimen of *Toxochelys*, and in no other semi-marine, or marine member of the Cheloniidæ, do we observe Trionychid-like foramina between the nuchal and first neural and pleurals. I may add that from recent measurements given by Hay it appears that amongst the several Toxochelyds *T. brachyrhinus* is next related to *T. latiremis;* and there is a question in my mind if the former is a distinct species, the differences in cranial proportion from *T. latiremis* being so slight as to be of very doubtful significance in specimens so invariably crushed at more or less varying angles as are the Niobrara fossils.

With the skull fragments and crushed [9th] left marginal of *T. serrifer* as recently figured for the first time by Hay (8), I am unable to identify the present handsome specimen. As the horn-shields of *T. serrifer* formed a very deep marginal notch leading into a pronounced sulcus (as indicated by Hay), there appear to be distinct differences. It is, of course, one of the difficulties of vertebrate paleontologists that species based

* University Geol. Survey of Kansas, pl. lxxxii, figure 3.

on such meager skeletal parts accumulate in the course of time; but surely we are permitted little diffidence in applying the laws of priority and nomenclature now in vogue to a handsome and reasonably complete fossil like that discussed in the present paper. Perhaps the day is not distant when fragments will be merely noted within generic limits, and then numbered and laid aside for a certain number of years before being arbitrarily dignified as the types of new forms. Assuredly such a method would simplify the study of extinct faunæ. The extreme difficulty of reaching accurate specific identifications after most painstaking comparisons and study of descriptions primarily based on fragmentary material, has been especially brought home to the writer in his consideration of the Upper Cretaceous Turtles of New Jersey, and he has great sympathy with Professor Marsh's oft repeated contention that the types of extinct vertebrates ought to be mainly founded on fairly complete forms.

With the isolated and imperfect skull of rather large and robust form named *T. procax* by Hay, as with that of *T. brachyrhinus*, no comparisons are afforded by the material thus far obtained.

From *T. (serrifer) stenoporus*, finally, *T. Bauri* differs distinctly. as shown by comparison with the posterior half of the carapace figured by Case.* From that and other specimens of *T. (serrifer) stenoporus* the present fossil differs in being of a larger type with relatively heavier marginals and larger pleural plates; also in the much more pronounced sutural union of the postero- and marginalo-pygal, which is reduced to peg-like junction in *T.* (*serrifer*) *stenoporus*.

Systematic Position of the Genus Toxochelys.

Because of the carapacial organization with much reduced pleurals and marginals, as well as certain plastral characters, all suggesting primitive relationships to the Cheloniidæ, it was first suggested by the writer on his discovery of the organization of the front leg of *Toxochelys latiremis*, that the Toxochelyds do not justly constitute a separate family of turtles, as proposed by Cope and held by Hay, but are better classified as a sub-family of the Cheloniidæ, the Toxochelydinæ. Recently Hay, while accepting the principle that the limbs do furnish "a test of the correctness of this disposition of the genus," interprets the evidence differently (7). He now reaches the conclusion that Wieland misinterpreted the limbs of *T. latiremus* (10), and that these, as in the Trionychid *Amyda spinifera*, were merely long fingered and webbed,

* Kansas Univ. Geol. Sur., vol. iv, plate lxxxiii.

and not markedly modified for marine life, so that *Toxochelys* "did not navigate the open seas."

In support of his contentions Dr. Hay uses a percentual method of comparison in which the humerus is conveniently and arbitrarily considered the unit in terms of which the length of the digits is expressed. This very effective means of comparison was first used by the writer in the case of forms in other ways related, and is, within limits, unquestionably useful in a diagrammatic sense. But Dr. Hay now mistakenly employs it in a far wider application than originally contemplated, when he reaches direct conclusions as to the front limb of *Toxochelys* by comparison with the Trionychid *Amyda spinifera*, thus:—

	Arm.			Fingers.				
	Humerus.	Radius.	Ulna.	1st.	2d.	3d.	4th.	5th.
Amyda	100	53	51	69	90	98	116	98
Toxochelys	100	58	50	51	73	100±	104±	70±

One might as well go on to prove that the "hawks-bill," *Eretmochelys imbricata*, is unable to "navigate the open seas". —For similarly:

	Arm.			Fingers.				
	Humerus.	Radius.	Ulna.	1st.	2d.	3d.	4th.	5th.
Amyda	100	53	51	69	90	98	116	98
Eretmochelys	100	53	44	49	89	128	105	44

Whence the following differences:

	Arm.			Fingers.				
	Humerus.	Radius.	Ulna.	1st.	2d.	3d.	4th.	5th.
Amyda	--	--	+7	+20	+1	--	+11	+54
Eretmochelys	--	--	--	--	--	+30	--	--

It is clear that save for that short thumb and long fourth finger of *Eretmochelys*, were this an extinct form, no conclusive evidence of the true flipper development would be afforded by such measurements as the above when considered alone. For it is a noteworthy fact that the disparity between the thumb and fourth finger of *Amyda* is +47 as against +53 in *Toxochelys*, and +56 in *Eretmochelys*. Yet as a true indication of unequal finger development, instead of disparity between only the short first and the long third and fourth fingers, as in *Eretmochelys*, there was in *Toxochelys* strong disparity between the short first and second and the long third *and fourth* fingers. There was also ulnar disparity.

All these fundamental numerical relations have been overlooked in Dr. Hay's criticism. He entirely ignores, too, the

fact that as a merely web-footed turtle *Toxochelys* would have been very unlike *Amyda*. For these percentual results must always be considered in connection with the humeral changes in the direction of marine forms, which are indicated in the thalassoid humerus of *Toxochelys*, as well as the enlargement of the pisiform to nearly the same size as in *Eretmochelys*. In short, it is evident that Dr. Hay overlooked important factors and that his views are untenable.

When I originally described the flipper of *Toxochelys* I was of the opinion that it represented the most primitive form yet discovered that could be called more distinctly marine than merely natatorial, long-fingered and web-footed; and now that I have had the present opportunity to briefly reconsider the subject I may say that I believe this interpretation in accord with the facts.*

Dr. Hay "readily grants that the fore limb of *Toxochelys* had entered on the early stages of those modifications which resulted in the production of flippers." But as clearly enough indicated by the facts, much more modification had been undergone, and the foot was more a swimming than a walking one. Whether the third to fifth fingers were encased in a leathery hide, or still retained some of their freedom of motion, as in distinctly webbed types, is open to some question; but nevertheless finger disparity, reduction of the 3d–5th claws, pisiform enlargement and humeral change had all been accomplished to such an advanced extent that the limb is to be regarded as a flipper, quite admirably fitting *Toxochelys latiremis* to range the great inland Niobrara Sea. And even were the anatomical facts of less certain interpretation, the *onus probandi* would rest on him who asserted the non-marine nature of those turtles which occur so widely distributed in as extensive a chalk formation of indisputably marine origin as the Niobrara Cretaceous.

It is very evident, therefore, that on the basis of limb organization *Toxochelys* is a member of the Cheloniidæ, and that as proposed by the writer on the basis of the general organization, limb structure, and relationships the genus is most conveniently placed in the Chelonidan sub-family Toxochelydinæ.

As a concluding word it may be added for the sake of clearness that no great diagnostic significance is attached to the presence of the epi-neural ossicles,—certainly not if they are to be regarded as vestiges of a disappearing system, likewise indicated in the genus *Lytoloma* of the Cheloninæ.

Yale Museum, New Haven, Conn., Sept. 26, 1905.

* In view of the great interest of the subject I will as early as convenient refigure the flipper of *Toxochelys* with all possible care. Dr. Hay is also of the opinion that the great turtles of the Fort Pierre, and perforce the Niobrara *Protostega* were likewise littoral and web-footed rather than marine. As will be incontestably demonstrated by the writer in a forthcoming Memoir of the Carnegie Museum of Pittsburgh, *Protostega* and *Archelon* were powerfully equipped for their marine habitat.

Measurements of Carapace and Plastron of Toxochelys Bauri.

(Yale Museum accession list 2823. Elements disarticulated and more or less altered in form by crushing in matrix. Recovered portions as shown in the accompanying figure 6 by the stippled surfaces.)

Length of carapace (estimated to within 1 or 2^{cm} ..... 53^{cm}
Breadth of carapace (greatest, as measured across the anterior end of the 6th neural) ..... 40+

	(*a*) Exact length on outer edge of carapace.	(*b*) Width measured at notch of the hornshield sulci.
Nuchal	12·0	--
1st marginal	6·0	2·5
2d "	5·0	2·5
3d "	5·9	2·8
4th "	6·0	-
5th "	6·5	2·8
6th "	7·0	3·3
7th "	7·5	--
8th "	8·0	4·5
9th "	7·5	4·5
10th "	7·0	4·5
11th "	6·8	4·5
Pygal	7·0	4·5

(The thickness and transverse sections of the marginals are approximately the same as in *Lytoloma angusta*. Owing to the crushing undergone by most of the marginals a closer approximation cannot readily be given.)

	Length on Median line.	Greatest width.
Nuchal	5·5	14·5
1st neural	3·8	3·8
2d "	4·4	3·7
3d "	4·4	4·0
4th "	4 6	4·4
5th "	3·4	4·5
6th "	5·0	4·0
7th "	4·0	3·8
8th "	2·5	3·5
9th "	1·5	3·5
(10th)"	2·5	3·4
Antero-pygal	4·5	5·9
(Postero-pygal)	(3·5)	(4·0)
Marginalo-pygal	4·5	6·5

1st epi-neural ossicle	3·5	1·7
2d " "	4·5	2·0
3d " "	3·9	1·5

(Thickness of 2d neural measured through carina, 1·4^{cm}.)

(The total height of the epi-neural ossicles is respectively, 15, 21, and 15^{mm}, the projection above the carina, 9, 12, and 9^{mm}.)

	(*a*) Length over curvature.	(*b*) Length of posterior sutural border.	(*c*) Median width.
Nuchal	---	[10]	--
1st pleural	15·0	6·5	5·7
2d "	18·5	8·4	5·5
3d "	19·5	8·4	5·0
4th "	19·5	8·2	4 9
5th "	19·0	7·7	4·8
6th "	17·5	6·9	4·5
7th "	14·5	5·1	3·8
8th "	11·5	2·2	3·8

(The average thickness of the pleurals is 50^{mm}. The distance between the bases of the rib-capitulae of the 7th pleurals is 4^{cm}. The large pleuro-marginal fontanelles are approximately one-half, or more than one-half the length of the pleurals which bound them. The hornshield sulci, save for the notched marginals, are indistinct.)

The Plastron. (Cf. figure 7.)

Length on median line	39±^{cm}
Greatest width	36±

(With added width of the inferior faces of the adjoining marginals, or 2^{cm} × 2, this measurement yields as the approximate breadth of the carapace 40^{cm}.)

Width (on antero-posterior line) of the marginalo-hyo-hypoplastral fontanelle	5·0
Length of hyo-hypoplastral suture	6·3
Least width of the hyo-hypoplastral bridge	11·0

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ART. XXXVII.—*Contributions to the Geology of New Hampshire. I. Geology of the Belknap Mountains;* by L. V. PIRSSON and H. S. WASHINGTON. (With Plate XI.)

Introductory Note.—Our object in this paper and in one to follow it is to present the results of a study made in the field and in the laboratory of the occurrence and characters of a group of igneous rocks from a locality about which little is known. Our field work was done in two visits to the area and covers a period of between two and three weeks, during which it was traversed and roughly outlined and the highest peaks and ridges ascended. This was sufficient to give a good general idea of its geology and of the various rock types. In the lack of a suitable base map on a sufficient scale, upon which to make record, more detailed and careful work was not warranted and would have enabled us to add little of interest to the general results presented in this paper. The map used and upon which our results are given is taken from that accompanying the Hitchcock Survey, referred to later, and which we have modified to some extent. The topography is more or less generalized and in places somewhat inaccurate, but it is the only one showing topography of which we have any knowledge and it has served as the basis of several topographic maps since published for the use of tourists which we have also consulted.

LOCATION AND GEOGRAPHY.

The Belknap Mountains form an elevated tract south and west of Lake Winnepesaukee in New Hampshire and lying in the townships of Gilford, Alton and Gilmanton. Although they are sometimes referred to as the "Belknap Range" they do not form a mountain range of the anticlinal type, being the irregular, eroded upper portion of a great intrusion of igneous rock of a generally granitic character. In its greatest length, which is northwest and southeast, the mountain tract extends about eleven miles and its width at the broadest point east and west is about six miles. In shape the mass is triangular, the long side facing the west composed of the main ridge which carries the highest summits, while an eastward extension produces the triangular shape. At the eastern end of the triangle there is an extension running southward. On the north and east sides the slopes descend into Lake Winnepesaukee; on the west and south into a much lower, irregularly hilly country. The drainage on the west is carried off by the Gunstock River, which in its course of about six miles runs due north at the foot of the mountain slopes in a valley cut along the contact

zone of the igneous rock mass. On the south the drainage is less clearly defined and is carried off through a series of small lakes which empty to the southward. On the other sides small brooks run into the lake. The mountains are quite generally covered with trees and brushwood on the steeper slopes; below these are generally open pasture fields, and the highest crests and summits are more or less bare rock exposures with small meadows between them. At the foot of the eastern and northern slopes, along the shore of Lake Winnepesaukee, runs the Lake Shore Railroad, a branch of the Boston and Maine Railway system, which ends at Lakeport-Laconia. These towns with Alton Bay at the south end of the lake and the village of Gilford are the most important places in the vicinity of the mountains, although the shore of the lake at their foot is thickly dotted with summer cottages and places of resort. Around them elsewhere is an open farming country and the high valley between the northern extension and the eastward one of Mount Straightback is also a cultivated area reached by a road over the mountains from Gilford to West Alton.

Historical.—The only reference in the literature to the geology of the Belknap Mountains which we have been able to find is the short description by Hitchcock.* He states that the mountains are composed of eruptive syenite similar to that of Red Hill in Moultonborough. He describes briefly a few localities, and mentions that in places it is in contact with porphyritic gneiss and mica schist. He thinks that the syenite has come up through a synclinal fault. Near the contact with the porphyritic gneiss it is brecciated and full of dark hornblendic spots. He alludes to a "trap" dike ten feet wide cutting the syenite in one place, and says that reddish feldspathic veins are common. This is an evident reference to one of the lamprophyric dikes and the felsitic ones. He also refers to a breccia which is found in one locality, the coarser syenites occurring as nodules in a rock resembling trap. The mass of diorite (camptonose) rock above the Gilford station on the lower west slope of Locke's Hill is not mentioned and was probably not seen by him. In Hawes'† report the rocks of this area are not mentioned, although he describes the syenite of Red Hill.

Geology of the Belknap Mountains.

The Belknap Mountains are formed of a mass of granitic igneous rock, the result of the upthrust of a great body of molten magma into the rock masses surrounding it, the latter being broken and displaced to permit of its entry. In sequence to this major event there were later upthrusts of other magmas

* Geology of New Hampshire, vol. ii, p. 607, 1877.
† Lithology of New Hampshire, loc. cit., vol. iii.

of different composition in small amounts which now appear as accompanying intrusive masses and dikes. Since then the superincumbent rocks have been removed by long-continued erosion, which has also bitten deeply into the igneous mass as well, but this has resisted better than those which surround it, and in consequence the igneous stock now projects as a rough mountain tract. Lastly, much material was removed at the time of the glacial invasion and the rock surfaces left scored and polished.

The enclosing rocks.—These are mostly gneisses and mica schists, rocks of metamorphic character. Although they do not especially concern us in this paper, a word or two may be added regarding them. On the eastern side the contact is with a heavy solid gneiss, composed of quartz, alkali feldspars and biotite, and often carrying red garnets. In its texture it is rather irregular, not presenting that evenness of aspect frequently shown by gneissoid granites, and it is possible that detailed study in the future may show that it is of sedimentary origin. It has a wide extension in this general region and has been called the Winnepesaukee gneiss by the Hitchcock Survey.

In Mount Major and Pine Mountain are two small masses of a porphyritic granite as shown on the map of the Hitchcock survey. In their report it is spoken of as the porphyritic gneiss. It covers a large area to the north of this region, where we have seen and studied it to some extent. By its general characters, contact modifications, etc., it is clearly an igneous rock—a granite which carries large, often huge, phenocrysts of orthoclase. It occurs in other parts of New England and is a type worthy of especial study. It sometimes has a pronounced gneissoid structure which evidently is often a fluxion texture, at other times it is due to dynamic shearing and in some places it is quite devoid of any gneissic character.

On the west and south the Belknap massif is in contact with micaceous gneisses, micaceous slates colored dark with organic matter and iron ore and with mica schist rocks evidently of sedimentary origin. The boundaries and names of these formations are those given on the Hitchcock map. The lack of printed symbols on this map connecting the legend with the outlined areas and the great similarity of colors makes it exceedingly difficult, in many cases impossible, to determine what some of these areas are meant to be, nor does the text afford much help in this direction. The formations are mentioned in many places, but there is no definite description of them given in a systematic manner by which their characters may be recognized. From what is stated,* however, we conclude that the rocks on the west belong to the Montalban series

* Op. cit., vol. ii, p. 600.

of Hitchcock, and they are so designated on the map. Where we have seen them they are mostly gray micaceous gneisses and mica schists.

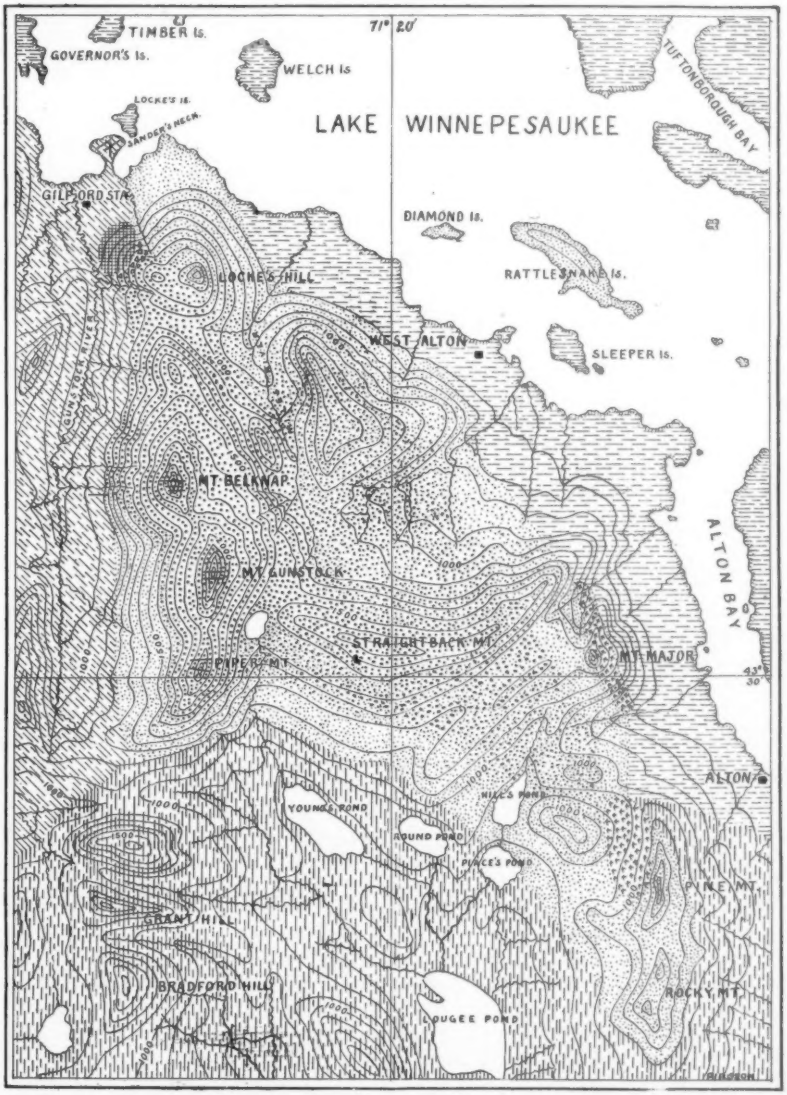
Geology of the main mass.—The greater part of the mountain group is made up of a coarse-grained hornblende syenite, a *hornblende-grano-pulaskose* in the new classification, whose characters will be given in a succeeding petrographical paper. It is this rock which composes the mass of Mt. Gunstock, of Mt. Belknap the peak next north of it and of the northern extension in Locke's Hill. It occurs also in the ledges exposed on the higher part of the road from Gilford to West Alton, where it crosses over the mountain. It also forms the higher parts of Piper Mountain south of Gunstock Peak, and it runs over towards Mt. Straightback. In Piper Mountain it assumes a somewhat porphyritic character. It is seen on the sides and crests of the main elevations in massive outcrops and exposures often several hundred feet across and is thus thoroughly laid bare. These surfaces show everywhere the planing and smoothing of glaciation. In none of them did we find the rock perfectly firm and unchanged. Everywhere its color ranges from a reddish to brownish, it tends to crumble under the hammer and in places it is loose and crumbling into coarse gravel. The chemical analysis shows however that this is not due to any chemical alteration of the constituent minerals, but to mechanical disintegration from the action of frost and weathering, which have tended to loosen the texture of the rock. Blasting would probably reveal excellent material at a few feet below the surface. We did not find any quarry openings in this rock-material; it is in general too high above the zone of cultivation to have made such work necessary. In only one place did we find this type at the contact zone against the older rocks, on the southwest slope of Locke's Hill in a little ravine where it is in contact with mica schist. It is here rather coarse, altered and not of typical composition.

Contact facies of fine-grained granite.—With the exception just mentioned, in all localities examined by us, we have found that at the contact with the enclosing rocks, not the syenite but a fine-grained granite (*grano-liparose*) is present. The lower slopes where the actual contact lies are in general so covered with glacial drift and soil, often with a more or less dense growth of vegetation, that it is masked and rarely seen, but immediately above where it should be this granite appears and beyond and above it the syenite. This we found to be the case in a number of places on different sides of the mass, so for example at the west foot of Mt. Gunstock, the west and south slopes of Piper Mountain, the northeast foot of Locke's Hill, at West Alton and on the southern prolongation of the

mass northeast of Hill's Pond. Hitchcock's description also gives clear indications of the same thing in other localities not visited by us. One of the best localities for the study of the contact that was seen by us is at the foot of the west slopes running down from the north end of Piper Mountain in the pasture fields south of Morrill's farm, where the path, by which Mt. Gunstock is generally ascended, begins. The mica schists and other rocks, which we infer make the formation shown by Hitchcock on his map as the Montalban, are full of pegmatite and fine granite stringers and dikelets and appear to be enriched in feldspar. As the contact is approached they change to a fine dark-gray gneiss which is cut by fine granite dikes. Higher up appears the syenite itself. The attitude and characters of the gneisses are such that they indicate quite clearly that they lie, thinning out toward the mountain, upon a rising slope of the igneous rock below and that the contact plane is therefore here not vertical but dipping away from the mountain. The syenite from the slopes above is that of the main type but finer-grained. At the south end of Piper Mountain the bordering granite has a faint but distinct gneissoid appearance. It is also to be noted that these bordering masses of granite are generally filled with spots and streaks of variable size of darker inclusions, which are no doubt fragments of the country rock thoroughly altered by immersion in the magma.

It appears to us that the best explanation for these fringing granite masses is to consider them a differentiated border facies, an endomorphic contact modification of the main type. They may not exist everywhere, but they have been so generally found on different sides, as seen by ourselves and indicated by Hitchcock, that the phenomenon seems difficult of explanation on any other basis. It is true that we have not been able on continuous exposures to trace the gradual merging of the granite into the syenite, because this should be done on the lower slopes, and for reasons given above these do not afford proper exposures for this purpose. We cannot affirm then positively that these are not a series of later eruptions which have broken out around the border of the previously intruded syenite, but in view of their disposition such an explanation seems unnatural, and especially so since they do not exhibit certain phenomena shown by an undoubted later intrusion of granitic magma on the western slope of Locke's Hill, which will be presently described. From the facts at our command, therefore, we are inclined to think the first explanation the more reasonable one and to regard the granite as a differentiated border mantle of the syenite. We also do not regard the granite border as having been produced by the melting up

Geologic and Topographic Map of the Belknap Mountains, N. H.



Syenite.	Granite.	Diorite and breccia.	Porphyritic Gneiss.	Winnepesaukee Gneiss.	Montalban Series? Cambrian?	Rockingham mica schist.

Scale 1 inch = 2 miles. Contour interval = 100 feet.

and absorption of the country rock with which the mass of syenite magma came in contact for two sufficient and convincing reasons. First, because as already shown, the surrounding rocks differ widely in character and in chemical composition in different places, while the granite border maintains everywhere essentially the same characters, and second, because in many places inclusions of the country rock are to be seen in it which, without regard to size, preserve all the sharpness and angularity of their original fragmentary form, thus showing that, although they have been much metamorphosed, melting of them did not occur. On the highest peaks and ridges and in the deepest erosive cuts into the mass it has been worn away and the main type of syenite appears. Its thickness was quite variable, and in a few places it did not appear at all. The line between the syenite and granite as shown on the geological map is therefore to be taken as a generalized expression of the existence of the two types and not as a definite geological boundary line, since for reasons just given this could not be definitely determined.

Gilford diorite area.—On our first visit to the region we found quite abundantly distributed in the form of bowlders in the fields and stone walls of the fences along the higher part of the land from Gilford over to West Alton, a most peculiar dark rock composed of large dark-brown hornblendes poikilitically enclosing ophitic feldspars. In field usage it is here called a diorite for purposes of geologic description; petrographically it is, as will be shown later, a grano-hornblende-camptonose, or in the older systems an essexite. On our second visit an especial search was made to locate if possible the occurrence of this type, and it was found to constitute a considerable mass on the lower west slope of Locke's Hill and not far from the Gilford station on the railway. Its area is small, probably not over half a mile in length north and south along the slope and less than that in breadth. On the north it rises in heavy ledges above a little spring drainage and on the west its lower slopes are covered with soil and debris, but above this it forms a rather well-defined bench on the lower mountain side and in rather prominent outcrops it is seen everywhere over the pasture fields which lie upon it. On the south it descends into a little ravine, a locality mentioned above in connection with the syenite, and is here in contact with the mica schists and gneisses. Its upper edge is in contact with the syenite, but the actual contact was everywhere covered so far as we could discover. We have traced it, however, to within a few yards distance, and it is then observed that the rock diminishes very strikingly in the size of its grain, especially so with regard to the large poikilitic hornblendes, and for this reason and others to be mentioned later we believe

it to be a later intrusion than the syenite and that it has broken up alongside of it. The upper contact with the syenite is, however, largely replaced by a remarkable breccia zone to be presently described. This rock varies considerably in characters from place to place, as will be described in a succeeding petrographic paper.

Breccia zone.—As just mentioned, the contact between the diorite and syenite above is occupied by a brecciated rock mass. The cement is a quartz-alkali feldspar rock much like the granite facies previously described; it has a sugar granular texture, and is of the character of rocks designated as aplites. In this are thickly scattered blocks of all sizes, which may attain an extreme dimension of four feet in length but which average perhaps a foot or two in diameter and descend from this size to minute fragments of a fraction of an inch. In some places they are so thickly crowded that their mass is much greater than that of the cement. In shape they are usually extremely angular and the sharpness of the angles has been perfectly preserved. In other cases they appear somewhat rounded as if partially melted, and are surrounded by darker aureoles richer in ferromagnesian minerals. It is remarkable, on the other hand, how some of the smallest fragments retain in some cases all their distinctness of outline. There are several different types of rocks among these included fragments. One common one is a dense black basaltic-looking type too compact for the component minerals to be seen, in which lie phenocrysts of mica and other minerals—a rock of well defined lamprophyric character. Other fragments are of the diorite mentioned above, while others are obviously pieces of gneisses and schists.

The determination of the relative age of this breccia and of the syenite and diorite is not easy. It would be simple to imagine that the latter is the older rock, that the syenite with its granite border broke up alongside of it enclosing masses of femic rock. If this view is adopted, then the basaltic, lamprophyric and granitic and felsitic dikes which cut the syenite must of course be separate and later intrusions and there would be four periods of eruption, in two of which, those of the diorite and the lamprophyric dikes, similar magmas were produced. The oldest rock, the diorite, is then also the most differentiated one, a fact contrary to general experience. Considering these points, we are inclined to believe the syenite the first and oldest, to place the eruption of the diorite next, which would also explain the distinct endomorphic contact modification it exhibits toward the syenite and make it contemporaneous with the lamprophyric dikes. Then came an eruption of granitic magmas, which also forms dikes in the syenite, one of

which broke up at the border of the diorite, involving masses of it in its various modifications and thus produced the breccia. If this view is adopted, there are but three periods of eruption and they follow the normal course commonly seen in such cases.

Dikes.—It has been observed by us that wherever the main types of igneous rocks are exposed over considerable areas in this mountain tract they are commonly cut by dikes, and the same is true of the border zone of the enclosing schists and gneisses. Except, however, in the highest parts of the mountains, such exposures are not very common nor are they of great size. It seems probable, therefore, that only a very small part of the dikes actually present in the region has been seen by us, the greater part being covered up by the heavy mantle of debris and glacial drift.

As is so often the case when the dikes are found to be a throng of satellites attendant upon a large body of igneous rock, they may be readily referred to two strongly contrasted groups. In one of these the rocks are light colored, strongly persalic and therefore almost devoid of ferromagnesian minerals; in the second the rocks are dark colored, salfemic, heavy and composed in very large, if not for the greater part, of ferromagnesian minerals. They are persalanes and salfemanes in the new classification or aplites and camptonites in the older ones.

The *persalane* dikes are found cutting the main syenite in all directions, of a generally pink color and varying in size from dikelets but a few inches in breadth to masses twenty feet wide. The bare exposed slopes and ledges of the upper part of Mt. Belknap were found cut by them in great abundance and it was here noticed that they often ended abruptly and appeared as if somewhat elongated roughly lenticular masses. They were often branched, were connected with others, anastamosed or formed reticulated systems, large and small together. Their small angular chippy jointing, light color on the weathered surface and flinty felsitic aspect clearly distinguished them from the massive granular rock they cut. These same characters were found repeated on the exposed surfaces of Mt. Gunstock and Mt. Piper, and in one place, about half way up Mt. Gunstock from Morrill's house, on the west slope above the spring, the ledges in a pasture field on an open shoulder of the mountain were found cut by a dike of this nature 15–20 feet in width and with north and south trend. It was also found that where the contact zone was exposed at the foot of the mountain slopes, as along the west side in the localities described above, that both the igneous rock and the enclosing schists and gneisses were cut by dikes and stringers

of persalic rock. While in the crest of the ridges and in the peaks these dikes vary in texture from dense felsitic to sugar granular granites, in the contact zone we observed only the latter, and they sometimes pass into varieties with pegmatoid texture.

With only a few exceptions all of these occurrences are on too small a scale to be shown on the map. The *salfemane* dikes were not nearly so numerous, but on account of the contrast made by their dark color appear more distinctly defined. They were also observed cutting the exposed rock surfaces on the tops of the mountains; there are several below the summit of Mt. Belknap on the southwest side and one six feet wide with porphyritic feldspars cuts the very highest point of the peak with east and west trend. Three or four of about the same size were found on the top of Mt. Gunstock and they were likewise observed on the crest of Mt. Piper. The lower slopes of the mountains are probably cut by them also, but the masses of debris and vegetation which cover them hide the exposures in which they might be seen.

They occur also in the surrounding rock masses in which the intrusion took place. Here again the exposures are difficult to find, but one place, Sander's Neck, a small promontory on the shore of the lake north of the mountains, presents considerable areas of the glaciated gneisses, and these we found traversed by several intersecting dikes of these salfemic rocks. As usual they were but a few feet in width. They occur in the mica schists which are exposed at the foot of the lower west slopes of Mt. Gunstock and Mt. Piper, and from what we have observed around the similar intrusive mass of Red Hill north of the lake, it seems probable that a more detailed study of the surrounding region would show a considerable number of them extending to relatively long distances from the central parent mass. Some of those mentioned above are shown on the accompanying map.

New Haven, Conn., and Locust, N. J., May, 1905.

Art. XXXVIII.—*The Fauna of the Chazy Limestone;** by Percy E. Raymond.

Introduction.

In several papers on the Chazy limestone, Brainerd and Seely have given sections showing the lithological characters and thickness of the rocks at various localities from Chazy, New York, south to Orwell, Vermont.† These authors have divided the formation into three parts, A, B, and C, of which A is the base and C the top. These divisions are founded partly on lithologic and partly on paleontologic grounds. Only a few species of fossils, however, were listed; hence it has been the object of the present writer to ascertain which are the common species in the Chazy, and to learn their stratigraphic and geographic distribution. For this purpose, detailed sections have been made at Crown Point, Valcour Island, and Chazy, and extensive collections have been obtained at other places in the Champlain and Ottawa valleys. The sections will be fully described in the Annals of the Carnegie Museum. In this place, however, only a synopsis of each is given.

Distribution.

The Chazy formation was named by Ebenezer Emmons‡ from the outcrops studied by him at Chazy village, New York, this locality, therefore, becoming the typical one for the formation.

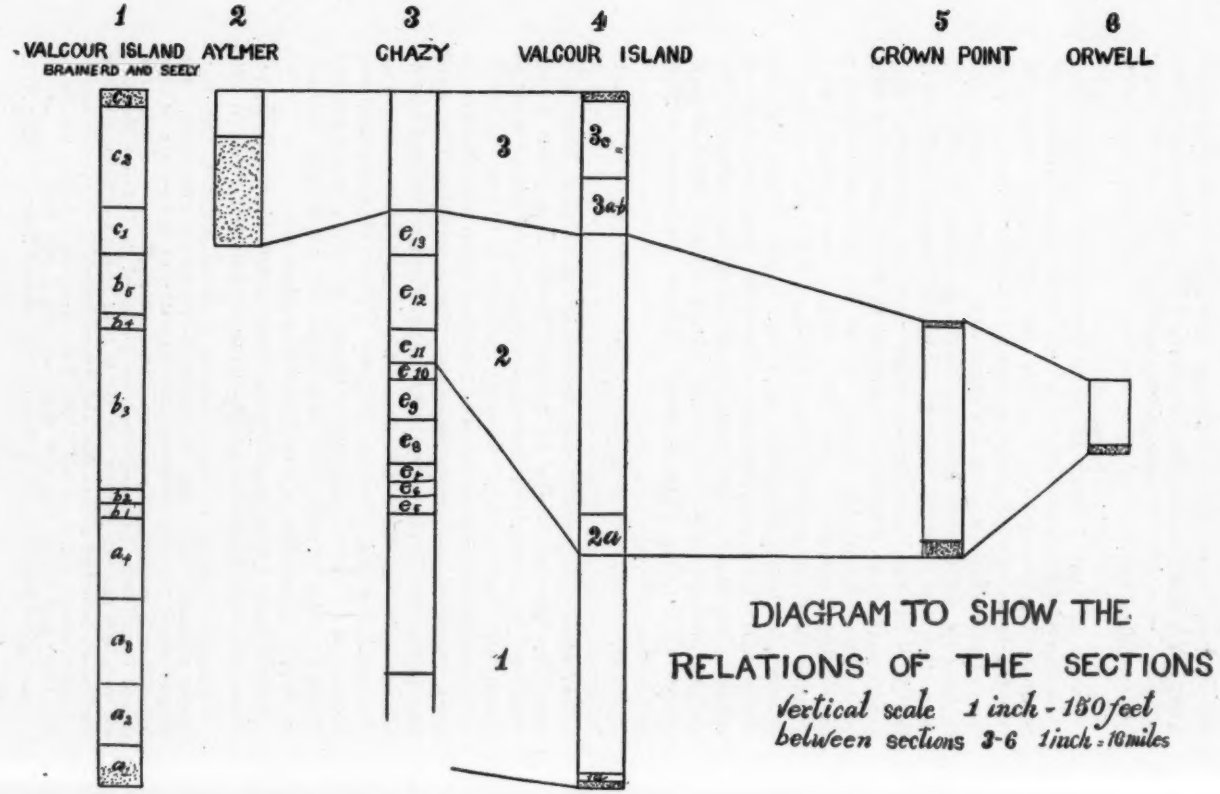
In stratigraphic position, the Chazy overlies the Beekmantown (Calciferous) and underlies the Lowville (Birdseye) member of the Mohawkian. It may be traced from Orwell, Vermont (along the Champlain Valley), to Joliette, north of Montreal, Canada. In the Ottawa Valley, it extends from Hawksbury west to Allumette Island, 80 miles northwest of Ottawa. The formation is seen again at the Mingan Islands in the St. Lawrence, where it covers a small area.

In the Lake Champlain region, these strata are mostly limestone, and the thickness ranges from 60 feet at Orwell to 890

* Abstract of part of a thesis presented to the Faculty of the Yale University Graduate School for the degree of Doctor of Philosophy. The detailed paper, with full discussion and illustration of species, will be published in early numbers of the Annals of the Carnegie Museum. For description of the trilobites here mentioned, see Annals of the Carnegie Museum, vol. iii, p. 328, and this Journal, vol. xix, p. 377. Other new forms noted in the text are described at the end of the present paper.

† Amer. Geol., vol. ii, p. 323, 1888; Bull. Geol. Soc. Amer., vol. ii, p. 300, 1891; Bull. Amer. Mus. Nat. Hist., vol. viii, p. 305, 1896.

‡ Geology of New York, Pt. 2, Report of the Second District, 1842, p. 107.


1
VALCOUR ISLAND
BRAINERD AND SEELY
2
AYLMER
3
CHAZY
4
VALCOUR ISLAND
5
CROWN POINT
6
ORWELL
c2
c1
b5
b4
b3
b2
b1
a4
a3
a2
a1
3
2
1
3c
3a-b
c13
c12
c11
c10
c9
c8
c7
c6
c5
2a
DIAGRAM TO SHOW THE
RELATIONS OF THE SECTIONS
Vertical scale 1 inch - 150 feet
between sections 3-6 1 inch = 18 miles

feet at Valcour Island. Further north the thickness is not definitely known. In the Ottawa Valley, the formation is usually from 100 to 200 feet thick and is about half limestone and half sandstone, the former usually overlying the latter. At the Mingan Islands, the thickness was estimated by Sir William Logan at about 300 feet, and the strata include both shales and limestone.

Lake Champlain Region.

As the typical Chazy is exposed in the Lake Champlain region, that area will be first taken up. In general, the Chazy rocks are seen as a narrow belt running almost north and south from Orwell, Vermont, to Joliette, Canada. The area is seldom more than 10 miles wide, and is not a continuous exposure, but occurs in small patches, in most cases evidently fault blocks, and the strata are usually inclined at a considerable angle. The principal outcrops are along the west side of Lake Champlain and on the islands in the northern part of the lake. South of Willsboro Point, there are scattered patches on both sides of the lake nearly to Fort Ticonderoga.

Faunal Divisions.

In the Lake Champlain region, three major faunal divisions of the Chazy may be distinguished. Within these, there are again various zones which are more or less local in geographical extent.

Division 1. The Hebertella exfoliata Division.—The strata of this basal division are chiefly light-colored, impure, rather coarse-grained limestones and frequently have shaly partings. The thickness varies from nothing at the south end of Lake Champlain to 300 feet on Valcour Island, 365+ at Chazy, and 225 feet on Isle La Motte.

The characteristic fossils are: *Hebertella exfoliata* sp. nov., *Orthis acutiplicata* sp. nov., *Strophomena prisca* sp. nov., *Scenella pretensa* sp. nov., *S. montrealensis*, *Palæacmæa irregularis* sp. nov., *Raphistoma immatura*, and *Scalites angulatus*. Other species occurring abundantly in this zone are: *Blastoidocrinus carchariædens*, *Bolboporites americanus*, *Zygospira acutirostris*, *Raphistoma stamineum*, *Lophospira subabbreviata*, *Bucania sulcatina*, and *Pseudosphærexochus chazyensis*. Those which occur only rarely in this division, but which thus far have not been found in higher divisions, are: *Lingula belli*, *Cyrtodonta solitaria* sp. nov., *Cyclonema? normaliana* sp. nov., *Eunema leptonotum* sp. nov., and *Heliomera sol*.

Of the 141 species in the Chazy whose range is known, 64 make their first appearance in this horizon and 23 are found in

all three divisions. This member is further marked by the appearance of the earliest of American Bryozoa, and these, unlike most Ordovician species, range throughout the entire formation above the sandstone.

Division 1 is characterized by the predominance of individuals and species of Brachiopoda. Fourteen of the 25 species of this group occurring in the Chazy of the Champlain Valley are found in this lowest member, while only 2 of the 16 pelecypods are represented. Exactly half the species of trilobites are also found here, but specimens are not common. Gastropods are more numerous, as half the species are represented and individuals of some forms are abundant. They do not occur in the lower strata, but are confined almost entirely to the upper part.

There are three zones in this division which are worthy of notice:—

Zone 1_a, or the *Orthis acutiplicata* zone, is near the base of the division and is found at Valcour Island and Isle La Motte. The characteristic fossils are: *Orthis acutiplicata*, *Rafinesquina incrassata*, *Isotelus harrisi*, and *Thaleops ovata*, all long rangers except the first.

Zone 1_b. The *Scalites angulatus* zone. The faunule of this zone is found at Plattsburg and Chazy. It is located near the middle of Division 1. The characteristic fossils are: *Scalites angulatus*, *Raphistoma immaturum*, *R. stamineum*, *Bucania sulcatina*, *Camarella longirostris*, *Illænus globosus*, and *Thaleops ovata*. Only the first two are restricted to this horizon.

Zone 1_c, the *Lophospira subabbreviata* zone, has been found only at Chazy, but is very strongly marked. It occurs about 75 feet below the top of Division 1. The characteristic fossils are: *Lophospira subabbreviata* and *Raphistoma stamineum*, both of which are very abundant. Of less importance are the rare *Schizambon? duplicimuriatus*, *Heliomera sol*, and *Clionychia marginalis* sp. nov.

Division 2. The Maclurites magna Division.—The strata of this middle division are usually heavy bedded, dark blue and grey, fairly pure limestones, with an occasional layer of grey sparkling dolomite or of light coarse-grained limestone. The layers near the middle usually weather into nodular masses, and the fossils are frequently poorly preserved and difficult to extract. The thickness varies from 200 feet at Chazy to 400 at Valcour Island, and decreases toward the south. The characteristic fossils are: *Maclurites magna*, *Rafinesquina champlainensis*, *Plæsiomys platys*, *P. strophomenoides* sp. nov., *Strephochetus*, *Eospongia varians*, *Eotomaria obsoletum* sp. nov., *Eccyliopterus fredericus*, *Bathyurellus minor*, *Glaphurus primus*, and *Leperditia limatula* sp. nov.

Thus far, the following fossils have been found only in this division, and most of them in but one locality: *Camarotœchia pristina* sp. nov., *Ctenodonta dubiaformis* sp. nov., *Clidophorus obscurus* sp. nov., *Cyrtodonta expansa* sp. nov., *Endodesma undulatum* sp. nov., *Scenella robusta* sp. nov., *Raphistoma undulatum* sp. nov., *Helicotoma vagrans* sp. nov., *Bucania bidorsata?*, *Trochonema dispar* sp. nov., *Subulites prolongata* sp. nov., *Holopea scrutator* sp. nov., *Eoharpes ottawäensis*, *Asaphus marginalis*, *Isotelus angusticauda*, *Isotelus? bearsi*, *Illœnus punctatus*, *Cybele valcourensis*, *Ceraurus pompilius*, *C. hudsoni*, and *Pseudosphærexochus approximus*.

This middle division is marked by an abundance of pelecypods, gastropods, and trilobites, and in this respect is sharply contrasted with the lower division. Of the 16 pelecypods, 13 are represented here. Of 35 trilobites, 27 are present.

Species of *Stromatocerium* and *Strephochetus* are common in these rocks, but are also abundant in the lower zone of the next division.

Zone 2_a. The *Malocystites murchisoni* zone. Thus far, only one subfaunule has been detected in Division 2, and that is at the very base. It is best developed at Valcour, but occurs also on Valcour Island. The zone is characterized by the great abundance of cystid fragments. The characteristic fossils are: *Glaphurus primus*, *Eoharpes antiquatus*, *Lonchodomas halli*, *Cybele valcourensis*, *Malocystites murchisoni*, *M. emmonsi*, *Glyptocystites forbesi*, *Palœocystites tenuiradiatus*, *Raphistoma stamineum*, *Maclurites magna*, *Plæsiomys strophomenoides*, and *Camarella varians*.

Division 3. The Camarotœchia plena Division.—The strata of this division are rather thin bedded, light grey, coarse-grained limestones, abounding in fossils. Near the base there are always buff-colored, pure, fine-grained dolomites and heavy bedded, coarse-grained blue limestones. The only fossil which is found throughout this division is *Camarotœchia plena*. Other characteristic fossils are: *Camarotœchia major* sp. nov., *Orthis ignicula* sp. nov., *Modiolopsis fabaformis* sp. nov., and *Glaphurus pustulatus*.

There is here a decided falling off in the number of gastropods and pelecypods, only 6 of the former and 5 of the latter being represented. There are about as many trilobites (16) in this division as in Division 1, and 8 of these are found in all three sections. The number of species of brachiopods is about the same in each of the three divisions, but they dominate the fauna in the first and third. In the former, one of the Protremata (*Hebertella*) is most abundant, while in the third division one of the Telotremata (*Camarotœchia*) predominates.

There are three well-marked zones in this division, as follows:

Zone 3_a, the *Glaphurus pustulatus* zone, is found at the base of Division 3, at Valcour Island, Chazy, Cooperville, and Isle La Motte. The characteristic fossils are: *Glaphurus pustulatus*, *Illænus globosus*, *I. erastusi*, *Isotelus harrisi*, *Remopleurides canadensis*, *Pliomerops canadensis*, *Amphilichas minganensis*, *Pseudosphærexochus vulcanus*, *Camarotœchia plena*, *Conocardium beecheri* sp. nov., *Bucania sulcatina*, and several cephalopods.

Zone 3_b, the *Camarotœchia major* zone, stands between 3_a and 3_c and its faunule is a transition between the two. *Camarotœchia* becomes more abundant and better developed, and fossils, while numerous, become fewer in species. The best development is at Valcour Island. The characteristic fossils are: *Camarotœchia plena*, *C. major*, *Hebertella costalis*, *Malocystites emmonsi*, *Malocystites* sp., *Palæocystites* sp., *Illænus globosus*, *Pliomerops canadensis*, *Bucania sulcatina*, *Raphistoma stamineum*, and *Isotelus obtusum*.

Zone 3_c. The *Modiolopsis fabaformis* zone. In this zone, *Camarotœchia plena* is abundant, almost to the exclusion of other species. The faunule extends to the top of the formation at Chazy, Grand Isle, and Valcour Island. The characteristic fossils are: *Camarotœchia plena* and *Modiolopsis fabaformis*.

Section at Chazy, New York.

The section at Chazy has a thickness of 732 feet, but the base of the formation is not shown.

Division 1.—The rocks carrying the fauna of Division 1 are well exposed in the ridges south of the village, near Tracy Brook. The thickness is 365 feet, and judging from the fauna at the base, at least 150 feet of strata are missing. *Hebertella exfoliata* is very abundant, especially below the horizon of *Scalites angulatus*. The latter zone is 217 feet above the base of the exposed section, and is zone 1_b of the generalized section. The most common fossils are: *Scalites angulatus*, *Bucania sulcatina*, *Raphistoma imnaturum*, *R. stamineum*, and *Thaleops ovata*. Higher up in the section, 275 feet above the base, is the zone of *Lophospira subabbreviata*, about 35 feet in thickness. This is zone 1_c of the generalized section. The gastropods are very abundant in the three localities at Chazy where this zone is exposed.

Division 2.—The strata of this division are about 195 feet in thickness, and are dark blue, impure nodular limestones, usually full of fossils which are frequently silicified. *Stroma-*

tocerium, *Eospongia varians*, *Rafinesquina champlainensis*, *Plæsiomys platys*, *Maclurites magna*, *Pliomerops canadensis*, and several cephalopods are common.

Division 3.—The *Camarotœchia plena* division is not very well developed along the line of the section at Chazy. The thickness is 156 feet, but a large part of the strata is covered with soil. At the base are about 25 feet of grey dolomite with almost no fossils. The remainder of the rock, as far as exposed, is an impure shaly limestone, abounding in *Camarotœchia plena*. Zones 3_a, 3_b, and 3_c can not be distinguished just at Chazy village, probably because the strata are so poorly exposed. About 3 miles southeast of this point, however, in a field near the lake shore, fine outcrops of zone 3_a occur, and here *Glaphurus pustulatus*, *Amphilichas minganensis*, *Illœnus globosus*, and the cephalopods are common.

Section at Valcour Island.

On Valcour Island, the whole of the Chazy is exposed, with a thickness of 890 feet. In one section along the south end, almost the entire thickness is shown, while nearly all the missing parts may be seen in other sections on the east and north sides of the island.

Division 1.—The strata of this division are well exposed on the south end. The thickness is 314 feet. At the base is a zone of sandstone and shale in which *Lingula brainerdi* is the common fossil. Other fossils are rare, *Isotelus harrisi* and a species of *Eccyliopterus* being the only ones thus far found. Above this zone is that of *Orthis acutiplicata*, 10 feet in thickness.

The *Scalites angulatus* zone is not exposed on Valcour Island, the rocks usually containing it being absent at the pebble beach on the south end of the island. The *Lophospira subabbreviata* zone is not well developed, but may be indicated by a fauna found on the middle of the west side.

Division 2.—The strata of this division are 406 feet in thickness and are usually compact, dark blue and grey limestones. The fossils are frequently coarsely silicified, but are almost always difficult to extract. At the base, zone 2_a, the *Malocystites murchisoni* zone, is well developed, and as the fossils weather out in this locality, some 40 species have been listed.

While the rocks of this division usually afford poor collections, yet in favorable localities they are found to be extremely rich in interesting species. Thus, one locality on the east side of the island has yielded 60 species of fossils, among them such rare trilobites as *Asaphus marginalis*, *Isotelus ? bearsi*, and *Remopleurides canadensis*, and many species of pelecypods.

Division 3.—This is especially well developed on Valcour Island. Zone 3_a is exposed in two or three localities on the east side. Zone 3_b is best developed about Cystid Point, the southeast point of Valcour Island, and zone 3_c is exposed both east and west of Black River Point on the north end. The division is 172 feet in thickness and carries *Camarotœchia plena* throughout. The faunules given for zones 3_a, 3_b, and 3_c, are those found on Valcour Island.

*Crown Point Section.**

The section at Crown Point is 305 feet in thickness. At the base is a zone 25 feet thick in which the strata are sandstone and shale, and the only fossil is *Lingula brainerdi*. The remaining 280 feet are impure blue and grey limestone, usually very fossiliferous. Division 1 is absent.

Division 2.—The fauna characteristic of this division is found all through the section at Crown Point. The characteristic fossils—*Maclurites magna*, *Rafinesquina champlainensis*, *Plœsiomys platys*, and *Leperditia limatula*—are very abundant, and the whole expression of the fauna is that of the middle part of the section at Valcour Island and elsewhere. Brainerd and Seely assign the lower 48 feet to their Division A, and the upper 57 feet to Division C, but faunally the whole section belongs together. *Camarotœchia plena* is absent, as are also the other fossils characteristic of Division 3. The upper 3 feet of the section are a coarse limy sandstone, with *Plœsiomys platys*, *Camarella varians*, *Raphistoma stamineum*, and *Isotelus harrisi* in a layer a foot thick at the top.

Orwell, Vermont.

A short distance northeast of Orwell village is the most southern exposure of the Chazy. At that place there are about 60 feet of strata, the fauna of which indicates that they belong to Division 2. Another locality near by shows sandstone and shale at the base of the formation.

North of the International Boundary the various divisions can not be followed in the published lists, but this is due to the fact that no sections have been made in that region. The lists published by Billings, Logan, and Ami, of the Canadian Survey, however, do show that fossils characteristic of all three divisions are found in that region. The Champlain Valley fauna of the Chazy, which will be designated as the typical one, is found as far north as Joliette, 35 miles north of Montreal and

* For detailed description of this section, see Bull. Amer. Pal., vol. iii, No. 14, 1902.

85 miles north of Chazy. To the west it is found as far as Hawkesbury, 75 miles northwest of Chazy and 55 miles west of Montreal.

Mingan Islands Region.

The fauna of the Chazy at Mingan Islands is very closely related to that of the typical Chazy of the Champlain Valley, as is shown by the following list of species common to the two regions:—

Bolboporites americanus.
Phylloporina incepta.
Columnaria ? ? parva.
Rafinesquina increassata.
Camarotœchia orientalis.
Camarella longirostris.
C. varians.
Orthoceras bilineatum.
O. multicameratum.
Pleisoceras jason.
Pliomerops canadensis.
Illœnus globosus.
Eoharpes antiquatus.

Ottawa Valley Region.

The Chazy deposits of this region have been described in detail by Logan,* Ells,† and Ami.‡ The formation is not more than 200 feet in thickness, usually less, and is divided into two parts, the lower including shales and sandstones, and the upper, limestones. It outcrops in a narrow belt extending along the north and south sides of the Ottawa River, from Hawkesbury west to Arnprior, and is again exposed south of Ottawa, whence another narrow belt runs to Cornwall, where it again turns northward. West of Arnprior there are a few outliers of the same formation. One large one occurs at Allumette Island, north of Pembroke, and another 10 or 15 miles south of this and west of Renfrew.

The coarse character of the sediments at the base of the formation in this region points to very shallow water and shore conditions and a probable erosion interval between the end of Beekmantown time and the deposition of the strata of Chazy age.

The writer has studied the rocks of this area chiefly in the vicinity of Ottawa and Aylmer, and the fauna there represented seems to consist of about 25 species, only 7 of which occur in typical Chazy deposits. The fauna of the sandstone at the Aylmer region is quite different from that found in the overlying limestone, and for that reason a list is here given of the species found in each. An asterisk denotes that the species is found also in the typical Chazy:—

* Geology of Canada, 1863.
† Rept. Geol. Survey of Canada, 1899.
‡ Ibidem; also Trans. Roy. Soc. Canada, vol. ii, 1896, vol. vi, 1900, and various other papers.

Sandstone.	Limestone.
Lingula lyelli.	*Lingula lyelli.*
**Camarotœchia plena.*	**Camarotœchia plena.*
**C. orientalis.*	**Rafinesquina alternata.*
Hebertella imperator.	
Modiolopsis breviuscula.	*Modiolopsis breviuscula.*
M. parviuscula.	*M. parviuscula.*
M. sowteri sp. nov.	
Ctenodonta parvidens sp. nov.	
Whitella canadensis sp. nov.	
**Archinacella? deformata.*	
**Raphistoma striatum.*	
**R. stamineum.*	*Raphistoma stamineum.*
Lophospira billingsi sp. nov.	*Orthoceras allumettensis.*
Bathyurus angelini.	*Bathyurus angelini.*
Beyrichia clavigera.	*Leperditia amygdalina.*
B. clavigera clavifracta.	**L. canadensis.*
	Leperditella labellosa.
Primitia sp.	*Isochilina ottawa.*
Isochilina sp.	*I. amiana.*
	Primitia logani.

It may be seen from the above parallel lists that there are only 6 species common to the sandstone and limestone divisions of this formation. In the limestones the ostracods are exceedingly abundant, often making up entire layers of the rock. The two divisions are intimately connected by very well-defined species, however, and none of the forms pass on into the overlying Lowville limestone.

In the Ottawa Valley, the most noticeable feature of the faunas is the absence of the cystids, Bryozoa, and Hydrozoa so common in the typical Chazy. The large number of species of ostracods and their great abundance are in marked contrast to the three or four species found in the Champlain Valley. This difference in the lithology and fauna has led the writer to suggest the name *Aylmer** formation for these deposits in the Ottawa Valley.

Summary on the Lake Champlain, Mingan Islands and Ottawa Valley Regions.

In the Lake Champlain region occurs the fullest development of both the strata and the fauna of the Chazy period, and three divisions based upon faunal differences may be recognized. The fauna of the Chazy at Mingan Islands, while only partly known, shows that the typical Chazy is also found in that region. West of Hawkesbury, Canada, a decided change

* Ann. Carnegie Mus., vol. iii, p. 380, 1905.

in the fauna is seen at L'Orignal, only 16 miles from Hawkesbury. Here is found a section less than 200 feet in thickness, with sandstone at the base and limestone in the upper portion. The fauna changes abruptly, several species occurring there which are unknown further east. The typical Chazy fossils found here are: *Camarotœchia plena*, *Raphistoma stamineum*, and *Malocystites murchisoni*. From this locality west to Allumette Island, a distance of 115 miles, the same succession of strata may be found, and about the same fauna. All through the Ottawa Valley the Chazy is represented by a formation which is sandstone at the base and limestone above. In its most western exposures, the limestones are absent and only the sandstone remains.

The base of the Chazy is always a sandstone, but this does not carry the same fauna in all regions, nor does the zone which rests upon it always have the same fauna. In the Lake Champlain region, the sandstone always contains *Lingula brainerdi;* in the Ottawa Valley, it carries a modified *Camarotœchia plena* fauna. At the type sections, *Lingula brainerdi* is at the base of the formation, while the *Camarotœchia plena* fauna appears 700 feet above.

Since the fullest development of limestone deposits of this age is in the region of Chazy and Valcour Island, New York, that must be the locality in which the Chazy sea persisted longest. From the evidence outlined above, it would seem that this sea was a shallow one, invading south and west over a slowly sinking land. Since the Chazy fauna is apparently developed less directly from the Beekmantown of the Lake Champlain area than from that of Newfoundland, and since there are many European types introduced into the Chazy, it seems probable that this sea was open to the east.

If the sea were thus invading upon the land, the sandstone would represent shore conditions. This is undoubtedly the case, for the sandstone in both the Champlain and Ottawa valleys frequently presents evidences of shore origin in cross bedding, ripple marks, and worm burrows.

If the sea were invading southward in the region now occupied by the Champlain Valley, the sandstone should be younger and younger in age as it is traced from north to south. That this is actually the case is shown by the faunas, for at Valcour Island all the strata of the *Hebertella exfoliata* division, 300 feet in thickness, were deposited before the *Maclurites magna* fauna became prominent, while at Crown Point this second fauna follows immediately upon the basal sandstone.

During the greater part of Chazy time, the transgression is southward, but later the shore began to move westward also. The region of the Ottawa Valley was then invaded, and the

sandstone brought with it a part of the *Camarotœchia plena* fauna. The date of this invasion to the west can be rather closely approximated. *Camarotœchia plena*, *Raphistoma stamineum*, and *Malocystites murchisoni* are found in the middle of the section at L'Orignal. At Valcour Island these species occur together in zone A_{m}, 775 feet above the base, thus showing that the formation in the Ottawa Valley represents the very latest part of Chazy time.

Ulrich and Schuchert, in their paper on Paleozoic Seas and Barriers,* bring out this idea of a Chazy sea invading westward and southward. They state: "With the earlier part of this subsidence [the Chazy invasion], the Atlantic invaded the continent westward. . . . The typical Chazy formation . . . bears evidence in its members of having encroached southward and westward in the arms, the latest beds . . . extending farthest south and west."

The Closing Period of Chazy Time.

In the preceding pages an effort has been made to show that in northeastern New York and in the Ottawa Valley, the Chazy sea invaded over a land surface of Beekmantown rocks, and that the base of the Chazy is a tangential sandstone; also that the invasion was first southward, covering the region of the Champlain Valley, and later westward along the locality of the present Ottawa Valley.†

Of the former extent of the formation throughout the St. Lawrence Valley or elsewhere, there is at present little evidence. Since the sea did not attain the region of Aylmer until very late Chazy time, it is probable that the formation never extended much further west than the known outcrops in that region (Allumette Island, etc.).

From a study of the stratigraphy and faunas it becomes evident that the upper portion of the Chazy is not represented in the region south of Valcour Island. Either these beds were never deposited there or they were eroded before the Lowville was laid down. The evidence is not of such a character as to prove definitely which did occur, but for reasons given below it seems more probable that the upper beds were deposited south of Valcour and later eroded. These reasons are as follows:—

* Rept. N. Y. State Pal., 1902, p. 639.

[† By these terms, Champlain Valley and Ottawa Valley, the writer does not intend to convey the impression that the Chazy deposits were laid down in narrow arms of the sea, or that the topography was then anything like that of the present time. It should be remembered that strata of post-Chazy age are involved in the Green Mountain uplift, and that there are indications that the Adirondacks did not exist in Ordovician time.]

First. All through the Champlain Valley, the Chazy is capped by a bed of sandstone 2 feet in thickness, and this may be interpreted as the invading base of the Lowville formation. From this it would follow that a period of erosion existed between the Chazy and Lowville formations.

Second. If the upper beds were never deposited south of Valcour, the Chazy sea after advancing slowly to the south to some point below Orwell, Vermont, must have then retreated to the northward. Such a recedence could have been caused only by an elevation south of Orwell, for there is no general retreat of the Chazy sea at this time, which is proved by the fact that at a still later period the sea advanced westward beyond Ottawa. That there was then no uplift in the south is shown by the fact that the Lowville sea invades from the southwest.* On the other hypothesis, which seems more probable, the sea would have invaded southward to the region of Orwell and after depositing there the final, or *Camarotœchia plena*, beds vanished from the area of Lake Champlain. During the latter part of Chazy time or after its close, the Stones River (Lowville) sea was invading from south to north and there was a land interval in the Champlain region, during which time some of the Chazy and Beekmantown beds were removed along the barrier region between Orwell and the Mohawk Valley.

Third. By taking the rate of decrease in thickness (11·25 feet per mile) of the *Hebertella exfoliata* division between Chazy and Valcour Island, to compute the probable southern extent of that division, it is seen that it would have reached only 26·6 miles south from Valcour Island. Therefore, at the same rate of decrease the base of the Crown Point section is 461 feet higher than the base of the Valcour Island section. That this rate of decrease can not be used, is shown by the fact that Division 1 at Isle La Motte is only 225 feet thick, which is less than at Valcour Island, while Isle La Motte is as far north as is Chazy. The only reliable data for an estimate of this character are the facts that there are 300 feet of the beds of Division 1 at Valcour Island and nothing at Crown Point. This is a thinning out of 7·3 feet per mile, which, on the other hand, is probably too small. On this basis, the bottom of the Crown Point section is at least 300 feet above the base of the Valcour Island section and the base of the Orwell section is at least 424 feet above it. If this minimum estimate of the height of the base of the Crown Point section above that of the Valcour Island section is accepted as a working basis, it will be seen that the former lacks the upper 285 feet of the formation. This is a gradient of 6·95 feet per mile

* See Ulrich and Schuchert.

to the top of the beds at Valcour Island. Taking the base of the Orwell section at 424 feet, the upper 407 feet are lacking. The thinning in the 17 miles from Crown Point to Orwell is 122 feet, or 7·1 feet per mile, while the gradient to the top of the Chazy at Valcour Island is 7·01 feet per mile. The close correspondence of these gradients and the small gradient of 7 feet per mile for 58 miles are significant, and seemingly indicate a base-leveled surface of this land during the Chazy-Lowville interval.

Representation of Chazy Time in other Regions.

The Chazy was formerly identified by various geologists as covering a large area, but more recently it has been held that while certain formations may have been laid down during Chazy time, the typical rocks and fossils of this period are restricted to the region of the Champlain and Ottawa valleys and the islands in the Gulf of St. Lawrence.

The St. Peter's Sandstone.

One of the formations which has long been correlated in time with the Chazy is the St. Peter's sandstone, which in Iowa, Minnesota, and parts of Illinois underlies the lowest member of the Mohawkian series. The fauna* of this formation is meagre and is contained in a few layers near the top. It is made up chiefly of Mollusca, all closely allied to Trenton forms. None of the species are found in the Chazy; hence no new light is thrown on the correlation by the later studies of the Chazy fauna. On lithological grounds, James has correlated it with the Chazy of the Ottawa Valley, but there are no species common to the two formations. From the close relationship of its fauna to that of the Mohawkian (Trenton) it seems probable that the St. Peter's was deposited during Stones River time.

Stones River Group.

In the Columbia, Tennessee, folio of the U. S. Geologic Atlas, Ulrich has stated that the lower part of the Stones River group, including the Lebanon, Ridley, Pierce, and Murfreesboro limestones, is to be correlated in time with the Chazy of New York State.

This statement is evidently based mainly on stratigraphic grounds, as Ulrich and Schuchert† have held that the Low-

* F. W. Sardeson, Bull. Minnesota Acad. Sci., vol. iv, No. 1, pt. 1, p. 64, 1896.

† Paleozoic Seas and Barriers, Rept. N. Y. State Pal.; Bull. 52, N. Y. State Mus., 1902, p. 633.

ville of New York is the northeastern representative of "the extreme top of the Stones River" group.

In the Columbia folio referred to above, Ulrich has tabulated the fossils of all the divisions of the Stones River group as developed in the middle Tennessee region. In the Lebanon formation, the upper member of the Stones River group which is there correlated with the Chazy, there are, according to the table, 37 species besides 10 undescribed Bryozoa. Of these 37 species, 7 are Bryozoa and 5 are not specifically identified. This large number of Bryozoa—17 species—at once suggests that the formation containing them is much more closely allied to the Trenton than to the Chazy. Leaving out of account the Bryozoa, which in the Ordovician nearly always have a very restricted vertical range, and the 5 forms not specifically identified, it is found that 17 of the 25 species remaining are Black River or Trenton forms. All the brachiopods, 4 of the 5 gastropods, and 2 of the 3 trilobites are species occurring in higher formations. Even if all the described species are included, 53 per cent of the species of the Lebanon formation are Black River or Trenton forms.

Below the Lebanon is the Ridley horizon, about 80 feet in thickness. Of the 9 species listed from this formation, 6 are found in the Black River.

Below the Ridley is the Pierce limestone with 12 species listed and 20 undescribed bryozoans. Only 11 forms are specifically identified and of these 30 per cent are Black River or Trenton forms.

The lowest member of the Stones River group is the Murfreesboro, which is about 60 feet in thickness and contains 24 species, 21 of which are identified. The fauna is composed principally of Mollusca, of which gastropods of the genera *Lophospira* and *Liospira* are particularly numerous. Of the 21 species, 11 are Black River or Trenton forms, so that 52 per cent of the species in this oldest member of the Stones River group belong to the Black River or Trenton.

This analysis may be tabulated thus:—

	Lebanon.	Ridley.	Pierce.	Murfreesboro.	Black River.	Trenton.
Lebanon	25	--	1	--	4	7
Ridley	1	3	--	--	1	1
Pierce	4	2	9	1	1	2
Murfreesboro	3	4	1	21	4	7

Of the 58 described species occurring in these 4 subdivisions of the Stones River, the above table shows that 27, that is, 46 per cent, occur in the Black River and Trenton formations.

Comparing the large percentage of forms common to the Stones River and to the Black River and Trenton with the low percentage—less than 5 per cent—of forms common to the Chazy and Trenton, it becomes evident that the Stones River and Trenton are faunally much more closely connected than are the Chazy and Trenton. This close relationship of the fauna of the Stones River to that of the Trenton, coupled with the stratigraphy, suggests that the whole Stones River is younger than the Chazy.

East Tennessee.

In east Tennessee the Maclurea limestone was correlated by Safford* with the Chazy or Black River of New York and Canada. While a large part of this limestone seems to be of Trenton age, a section around Lenoirs has afforded the writer a small fauna containing fossils characteristic of Division 2 in the Lake Champlain region. This region needs further study before definite correlations are made.

Description of New Species.

BRACHIOPODA.

Lingula columba sp. nov.

Shell small, oval in outline, gently and uniformly convex. There are no flat slopes and the front is semi-circular in outline. The posterior end is somewhat triangular, the beaks pointed. The surface is covered by very numerous and prominent concentric striæ, no radiating lines showing except when the surface is exfoliated.

One specimen is 10^{mm} long and 7^{mm} wide; another is 7^{mm} long and 5^{mm} wide.

Locality.—East side of Valcour Island at Chazy, and on Isle La Motte. Type in Yale University Museum.

Camarotœchia pristina sp. nov.

Shells small, transversely oval to subcircular in outline. Both valves moderately and uniformly convex. The dorsal valve has a low fold and the ventral valve a shallow sinus, which is noticeable only toward the front of the shell. There are 10 to 14 strong rounded plications, 4 on the dorsal fold and 3 on the sinus. The 2 plications in the middle of the fold are smaller than the 2 outside ones and the median plication of the ventral valve is the weakest, which is the direct opposite of the state found in *Camarotœchia orientalis.*

Locality.—Valcour Island and Chazy, New York. The type is in the Carnegie Museum.

* Geol. Tennessee, 1869, p. 236.

Camarotœchia major sp. nov.

Outline somewhat oval, widest a little in front of the middle. Dorsal valve with 10 to 14 strong angular plications. The ventral valve has 9 to 14. The fold and sinus are hardly defined except by a gentle arch in front, but are outlined on both valves by a pair of very strong plications. The dorsal fold bears 5 plications, the middle one of which is the strongest. The ventral sinus has 4 plications, the 2 largest in the middle. The ventral beak is somewhat incurved.

Length of a good specimen 23^{mm}; width 21^{mm}.

Locality.—Southeast point of Valcour Island, New York. The type is in the writer's collection.

Strophomena prisca sp. nov.

Shell of medium size, resupinate, nearly as long as wide. Ventral valve convex at the umbo, flat in front to about the middle of the valve and then concave. Dorsal valve flat on the umbo and convex in front. Cardinal area narrow, the wide delthyrium mostly covered by the deltidium, with a small opening for the pedicle at the beak. Muscle area in the ventral valve small, confined to the space under the umbo. Surface marked by fine alternating striæ, the prominent ones being very numerous and increasing by implantation. Between each pair of the strong striæ are two or three finer ones and the whole surface is crenulated by fine concentric striæ. The dorsal valve sometimes shows very small concentric wrinkles.

One specimen is 15·5^{mm} long and 20^{mm} wide; another 16^{mm} long and 19·5^{mm} wide.

Locality.—All the specimens are from Valcour Island, New York, and are in the writer's collection.

Orthis ignicula sp. nov.

Shell transversely oval in outline, usually but little wider than long. Hinge width nearly equal to the greatest width of the shell. Ventral valve strongly convex, the area high and a little incurved.

Dorsal valve nearly flat, with a broad depression near the front. Area of dorsal valve rather wide. Cardinal process small. Delthyrium narrow and open. Surface marked by 16 to 25 direct rounded plications which increase by implantation.

Locality.—Found rarely on the southeast corner of Valcour Island, New York.

Orthis acutiplicata sp. nov.

Shell small, almost circular in outline. Hinge width not quite equal to the greatest width below. Cardinal area of ventral valve high and a little retrorse. Foramen narrow and open. Ventral valve strongly convex, highest on the umbo. Dorsal valve convex on the umbo, flattened in front. There is a shallow sinus on this valve, which is narrow at the beak but becomes wider in front. Surface marked by 12 to 15 sharp simple striæ separated by spaces wider than the striæ.

Locality.—South end of Valcour Island. The types are in the writer's collection.

Plæsiomys strophomenoides sp. nov.

Shell small, ventral valve convex at the umbo, concave in front. Dorsal valve convex, with a narrow sinus on the umbo, but frequently with a slight fold on the front of the shell, in which case the ventral valve shows a shallow median sinus.

Surface marked by numerous fine striæ, which increase by bifurcation and implantation. There are usually 7 or 8 in the space of 2 millimeters on the middle of the front of the shell.

The cardinal area of both valves is low. The ventral area has a narrow delthyrium, which at the apex is perforated for the passage of the pedicle. The interior of the ventral valve shows small but strongly marked muscle scars under the umbo. The muscle area is roughly quadrate and contains a pair of strong diductor scars, between which are the narrow adductor attachments. Posterior to the latter is a deep pedicle scar. The lateral edges of the diductor scars are bounded by strong plates, which run back to support the dental lamellæ. The interior of the dorsal valve shows a robust, simple cardinal process and small dental sockets bordered by strong plates which do not greatly diverge. In front of the cardinal process is a low but strong median ridge, on either side of which are the four scars of the adductor, not, however, deeply impressed.

Locality.—Crown Point, Plattsburg, and Valcour Island, New York. The type is from the quarries near the Plattsburg Fair Grounds and is in the Carnegie Museum.

Hebertella exfoliata sp. nov.

This shell is distinguished from *Hebertella costalis* by its smaller size, more pronounced dorsal sinus, and by the fact that the striæ are always simple instead of bifurcating. It differs from *H. borealis* in its smaller size, and in the narrow and deep dorsal sinus.

Locality.—Common in the lower part of the Chazy at Chazy and Valcour Island; also at Plattsburg, Valcour, and Isle La Motte, New York. The type is in the Carnegie Museum.

Orthidium lamellosa sp. nov.

Ventral valve strongly convex, the area high and curved backward. Delthyrium narrow and open. Along the middle of the valve is a narrow and shallow depression in which there is one plication. The outline of the shell is subquadrate. The greatest length is at the hinge and the cardinal extremities are slightly alate.

The dorsal valve has a narrow median sinus, which extends from the beak to the front and usually contains 2 plications. There are commonly about 20 sharp plications, which are crossed by strong concentric lamellæ of growth.

An average specimen is 3^{mm} long and $5{\cdot}5^{mm}$ wide.

Locality.—Valcour Island, Chazy, and Crown Point, New York. The types are in the Yale University Museum.

PELECYPODA.

Ctenodonta peracuta sp. nov.

Shell small, longer than high, the beak about one-third the length from the posterior margin. Front rather drawn out, as in *Ctenodonta nasuta* Hall. The greatest convexity is at the umbo, the posterior slope very gradual. Both slopes to the hinge abrupt, but that to the basal margin gentle. One specimen is 12^{mm} long and 9^{mm} high. This species may be distinguished from the succeeding one by its more depressed valves and by the prolongation of the anterior margin into a somewhat nasute extension.

Locality.—Found in some numbers in the trilobite layers at Sloop Bay, Valcour Island, and in the middle of the Crown Point section. The type is in the writer's collection.

Ctenodonta limbata sp. nov.

Outline nearly circular, the beak back of the middle. Greatest convexity near the middle of the valve; all slopes steep. The cast shows a few faint lines of growth.

Length of largest specimen 10^{mm}; height 10^{mm}. A smaller one measures 8×8^{mm}.

Locality.—All the specimens are from the trilobite layers, Sloop Bay, Valcour Island. The types are in the Yale University Museum.

Ctenodonta dubiaformis sp. nov.

Shell small, moderately convex, beak subcentral. Greatest convexity on the umbo, the slope from it to the base nearly flat. Basal margin nearly straight. Anterior end nasute and

longer than the posterior, which is regularly rounded. Front margin rather acute. All the specimens are of casts without trace of hinge teeth, muscle scars, or surface markings.

Largest specimen: Length 19^{mm}; height 10·5^{mm}. Another: Length 17^{mm}; height 9^{mm}.

Locality.—Sloop Bay, Valcour Island. The type is in the Yale University Museum.

Ctenodonta parvidens sp. nov.

Shell oval in outline, usually flattened, but specimens from the harder layers show considerable convexity below the umbo, with regular slopes to the anterior, posterior, and ventral margins. The cast shows the impression of numerous very fine teeth on the hinge, but the number can not be counted as the beak is always flattened down upon the impression of the hinge. One specimen exhibits 5 teeth on the anterior portion of the hinge. Another shows 7. The surface is marked by very numerous fine concentric lines of growth.

Locality.—In shales and limy clays at the Hog's Back, Ottawa.

Clidophorus obscurus sp. nov.

Shell small, longer than high, not very convex. Basal margin nearly straight, anterior margin regularly curved, posterior end compressed, the margin acutely rounded. In front of the beak the cast shows a short clavicular impression, which extends about half the distance to the lower margin.

Length 6^{mm}; height 4^{mm}.

Locality.—Trilobite layers, Sloop Bay, Valcour Island. The type is in the Yale collection.

Cyrtodonta tranceps sp. nov.

Shell roughly rectangular in outline, strongly convex at the umbo and along a ridge which runs diagonally across the shell to the lower side of the posterior margin. In front of this ridge there is usually a slight depression running from the umbo to the middle of the lower side. The posterior margin is regularly rounded, the lower side straight or slightly indented. The anterior end extends a short distance in front of the beak. The slope to the hinge is flat and rather steep. The slope to the front and base is gently convex and more gradual. The surface is marked by numerous concentric lines.

Locality.—Valcour Island, New York. The type is in the collection of the Carnegie Museum.

Cyrtodonta solitaria sp. nov.

Shell roughly triangular, the beak a little behind the anterior end. Hinge line short. The anterior margin is narrow and rounded, the base long and straight, incurved at about 45° with the hinge. Posterior regularly rounded. Shell only moderately convex, the slope to the posterior end gradual and to the front nearly flat.

Length 15^{mm}; height 12·5^{mm}. Surface marked by concentric lines of growth.

Locality.—Ledge in pasture near Tracy Brook, Chazy, New York. The type is in the Yale collection.

Whitella canadensis sp. nov.

Shell small, convex, subrectangular in outline. A prominent ridge extends from the beak to the lower posterior corner. From this ridge the slope to the cardinal and posterior margins is abrupt, while there is little slope to the front until a point in front of the beak is reached, when the slope is suddenly deflected. The surface is marked by concentric undulations.

Locality.—Aylmer sandstone, Aylmer, Quebec.

Clionychia marginalis sp. nov.

Both valves moderately convex, the umbones somewhat depressed, but increasing rapidly in height, the greatest thickness of the valves being at about one-third the distance from the beak to the lower margin. Hinge line short. The posterior margin is broadly rounded, the lower margin semi-circular. The front is almost straight. The greatest convexity is along a line parallel to the front. The posterior and lower slopes are gentle, but the front slope is abrupt, almost 90° with the plane of union of the valves. The surface is marked by very fine concentric striæ.

One specimen is 20^{mm} long and 26·5^{mm} high.

Locality.—Chazy and Valcour Island, New York. The type is in the Yale collection.

Ambonychia? curvata sp. nov.

Shell large, both valves very strongly convex, especially along the region of the front and middle of the valves. Beaks small, incurved, directed a little forward. Anterior slope abrupt and overhanging. Posterior and bottom slopes rather steep. Posterior wing short. The posterior margin is almost straight. The anterior margin is regularly curved. The length and breadth are nearly equal.

A large specimen is 27^{mm} long and 26^{mm} high. Another is 43^{mm} long and 39^{mm} high. A small one is 10^{mm} long and 10^{mm} high.

The species is easily recognized by the curved anterior margin and the great convexity. The line of greatest convexity follows the anterior margin. There is an elongate posterior muscle faintly outlined on some of the casts. The general appearance is somewhat like *Ambonychia amygdalina* Hall.

Locality.—Valcour Island, Chazy, and Sloop Island, New York.

Conocardium beecheri sp. nov.

Shell very small but robust, with long anterior and short posterior wings. The region of greatest convexity is from the beak straight to the base of the shell, the curvature decreasing gradually forward to the anterior wing and rather abruptly backward to the posterior wing. The anterior wing is long, with straight lower margin. The posterior wing is short and narrow, joining the body at a large angle. The surface is marked by 7 or 8 large plications on the anterior wing, 15 or 20 smaller ones on the body of the shell, and 3 or 4 very large ones on the posterior wing. The dimensions of 2 specimens are: First, length 6·5^{mm}, height 5^{mm}; second, length 6^{mm}, height 4^{mm}.

Locality.—Sloop Island, east of Valcour Island, New York; also on Valcour Island and at Chazy, Clinton County, New York.

Modiolopsis fabaformis sp. nov.

Shell small, thick, with a strong ridge extending from the umbo to the lower posterior angle. In front of this ridge is a deep depression, which continues to the middle of the ventral margin, making that margin sinuate. Anterior ear small, convex. Anterior margin narrowly rounded. Posterior margin broadly rounded, not oblique as in *Modiolopsis breviuscula* and *M. parviuscula*. The surface is marked by numerous concentric lines of growth.

Locality.—Common in the upper layers at Valcour Island. The type specimen is in the writer's collection.

Modiolopsis sowteri sp. nov.

Shell of medium size for the genus, rather convex, with a strong ridge running back from the beak to the lower posterior angle. Toward the front is a slight depression running from just ahead of the beaks a little backward to the basal margin. In front of the beak is a very deeply impressed anterior scar,

which on the internal cast is represented by a rounded conical elevation. The posterior scar is large and close to the hinge line.

Length 51^{mm}, height 28^{mm}.

Length 37^{mm}, height 20^{mm}.

Locality.—From the Aylmer sandstone, about 60 feet above the high-water mark of Lake Deschenes, at Aylmer, Quebec. Collected by T. W. E. Sowter, for whom it is named. The type is in the Yale University Museum.

GASTROPODA.

Archinacella? deformata (Hall).

Orbicula ? deformata Hall, 1847, Pal. N. Y., vol. i, p. 23, pl. iv bis, figs. 10a, 10b.

Metoptoma ? dubia Hall, ibid., figs. 11a, 11b.

Stenotheca dubia Whitfield and Hovey, 1898, Catalogue of Type and Figured Specimens in the American Museum of Natural History, Bull. Amer. Mus. Nat. Hist., vol. xi, p. 58.

An examination of the types shows that Whitfield was right in regarding the specimen named *Orbicula? deformata* by Hall as identical with *Metoptoma? dubia*, which Hall described on the same page. His species, however, must take the first specific name applied to it, even though given under the misapprehension that it was a brachiopod instead of a gastropod.

The generic reference is uncertain as no specimens have been found which show either muscle scars or pronounced surface markings. It does not seem possible to leave it either in the genus *Metoptoma*, where Hall doubtfully put it, or in *Stenotheca*, where it was placed by Whitfield. In general form it most resembles the numerous species of *Archinacella* described by Ulrich and Scofield, to which it may be referred until better examples are obtained. The individual specimens of this shell are abundant and the characters are quite constant. It is easily recognized by the low form and almost marginal position of the beak.

Scenella pretensa sp. nov.

Shell small, aperture narrowly elliptical in outline. Height about equal to the greatest diameter of the aperture. Beak small, pointed backward, but not incurved. Posterior slope nearly straight. Anterior slope convex above, becoming straight below. Surface smooth, except for a few low concentric undulations near the base. Beak a little behind the middle.

The greatest diameter is 11^{mm}; the shortest is 6·5^{mm}. Height 11·5^{mm}.

Locality.—Rare at Chazy, New York, in the Lower Chazy layers south of the lime kilns. It occurs also at Lenoirs, Tennessee.

Scenella robusta sp. nov.

Shell large, aperture nearly circular. Beak obtuse, rather high, and located a little behind the middle. All slopes about equal and all convex, the whole shell somewhat hemispheric. The specimens are all casts, showing no surface markings of any sort.

The only perfect example is 17^{mm} in greater diameter and 16^{mm} in lesser. A much larger one is represented by a fragment 27^{mm} long, but it had evidently been considerably larger.

Locality.—Valcour Island, in the Middle Chazy beds. Rare. The type is in the writer's collection.

Palæacmæa irregularis sp. nov.

Shell rather large, irregular in outline, generally subcircular, but never with a smooth curve. Beak obtuse, almost central, sometimes a little back of the center. All slopes about equal, generally almost straight, but occasionally a little convex. Surface marked by numerous fine concentric lines of growth, which follow the irregular form of the aperture. Usually there are a few radial folds and some irregular depressions and pits which do not follow in symmetrical arrangement.

The greater diameter of the aperture is 26^{mm}; the lesser is 10^{mm}. The aperture of another is 19^{mm} long, 18^{mm} wide, and the apex is 9^{mm} above the aperture.

Locality.—Common in lower layers at Chazy, New York.

Helicotoma vagrans sp. nov.

Shell small, somewhat *Maclurea*-like, the spire flat and depressed below the plane of the highest points on the upper surface. Outer edge of the body whorl angular, raised as a high sharp ridge toward the aperture. Lower surface of the shell rounded, the umbilicus wide. Aperture large, quadrilateral, angular above, rounded below. Surface marked by fine lines of growth, which turn back on crossing the angle of the upper surface.

Locality.—A rare fossil at Valcour Island, New York. The type is in the writer's collection.

Eotomaria obsoletum sp. nov.

Shell small, trochiform, with about four volutions. The upper part is conical, the volutions are flat, and the sutures only

slightly impressed. The lower surface is convex, umbilicus small. The present specimen is a cast and shows no surface markings. Aperture large, angulated on the side, rounded below.

Locality.—Crown Point and Valcour Island, New York. Very rare. The type is in the writer's collection.

Lophospira rectangularis sp. nov.

Shell fairly large, with 5 volutions. Body whorl very large, spire small. Last 3 whorls with sides parallel to the axis of the shell. Aperture large, nearly circular. Upper lip nearly straight, meeting the straight outer lip at an obtuse angle. The inner and lower sides of the aperture are rounded. The umbilicus is very small.

All the specimens in the collection are casts of the interior and do not show anything more than traces of the surface markings. They were probably the same as in *Lophospira subabbreviata.*

Locality.—A rare species from Valcour Island, New York. The type is in the writer's collection.

Lophospira billingsi sp. nov.

Shell of 4 volutions, body whorl very large, spire low, whorls angular, sloping gently from the suture to the keel. The under side of the body whorl is rounded and strongly convex. The umbilicus is small. The aperture is entire, the inner and lower lips are rounded, the upper lip is straight from the suture to the keel, sharply angulated at the keel and nearly straight for a short distance below it. The surface is covered by rather coarse lines of growth, which run first forward and cross the upper side of the volution diagonally and backward, again turning forward after crossing the volution. On the under surface of the whorl, the striæ turn back to the umbilicus.

Locality.—From the Canadian Pacific Railroad cut, east of Main street, Aylmer, Canada. Named for W. R. Billings of Ottawa, an enthusiastic student of the Chazy.

Cyclonema? normaliana sp. nov.

Shell small, elongate trochiform, with 4 or 5 whorls, which enlarge gradually. Sutures not deeply impressed and volutions almost flat sided. The under surface of the last whorl is flat or slightly convex. The surface is marked by 3 or 4 revolving raised lines or low keels.

Locality.—Lower Chazy, near the Normal School at Plattsburg, New York.

Eunema leptonotum sp. nov.

Shell small, with about 4 whorls, which increase gradually toward the base. The whorls are all convex, the suture is deeply impressed. The first 3 whorls are smooth and *Holopea*-like. The fourth, or body, whorl is ornamented by 5 sharp revolving ridges, equally spaced. These ridges are crossed by fine vertical lines, which are close together and give the ridges a pitted appearance. The aperture is not seen.

The height of the shell is 5^{mm}; the width of the body whorl 3·5^{mm}.

This shell is not uncommon in the Chazy, but on account of its small size and liability to exfoliation it is often overlooked or is in too imperfect a condition to be positively identified.

Locality.—Lower Chazy, at Chazy, New York. The type is in the Yale collection.

Trochonema dispar sp. nov.

Shell rather large, consisting of 3 whorls with depressed spire and very large body whorl. The suture is very deep. The whorls are almost free. The body whorl has a flat revolving band on the outer side. The top is flat and sloping and the lower side strongly convex. The surface markings are not shown. The umbilicus is large in the cast, but rather small in testiferous specimens.

Locality.—Fairly common on Valcour Island, in a locality at the south end. It is rare elsewhere on the island and at Chazy, New York. The type is in the writer's collection.

Subulites prolongata sp. nov.

Shell small, elongate, fusiform, with about 6 (?) whorls (specimen shows body whorl and 3 above). The whorls are long and narrow, decreasing slowly and regularly toward the top. The body whorl is about equal to the length of the 2 whorls above it and is contracted below. The aperture is not shown.

The length of the fragment is 29^{mm}; the greatest thickness is 5^{mm}. Probably the total length was about 35^{mm}.

Locality.—Sloop Bay, Valcour Island. The type is in the Yale collection.

Holopea hudsoni sp. nov.

Shell usually large, with about 4 whorls. The body whorl is large, robust, expanding rapidly. The spire is fairly long, whorls strongly convex, sutures very deep. Aperture nearly circular, entire; the outer lip thin, the inner lip free from the body whorl. The umbilicus is small.

The surface is usually smooth. Some casts show traces of lines parallel to the margin of the outer lip. These lines run a little forward from the suture, continuing in this direction over the bulge of the whorl, then curve a little backward and finally forward again at the lower end.

Locality.—Rather common at Crown Point, Valcour, Valcour Island, Plattsburg, and Chazy, New York. The type is in the writer's collection.

Holopea scrutator sp. nov.

Shell of medium size, about 3 whorls, the body whorl constituting by far the larger part of the shell. Spire depressed, sutures not deep. Aperture elongate, oval, entire. Umbilicus small.

The specimens usually occur as casts, but on a few the shell is preserved. It shows no markings except a few growth lines, which run diagonally back across the whorl. When the specimens are exfoliated the suture lines are much more deeply impressed and the spire appears higher.

This shell is easily distinguished from the preceding by the low spire, the shallowness of the sutures and the general depressed form of the shell.

Locality.—Common at Valcour Island and Chazy, New York. The type is in the Yale Collection.

Conularia triangulata sp. nov.

Shell small, slender, slightly curved, 6-sided, but 3 of the sides are so narrow as to give the shell an almost triangular cross section. The narrow faces alternate with the wide ones, the former truncating the angles which the latter would make if prolonged till they met. Along each of the faces, both wide and narrow, is an elevated line, which extends longitudinally along the center of the face. The surface markings consist of numerous fine tranverse striæ, which bend backward on crossing the raised line.

The best specimen in the writer's collection is broken at the tip and at the aperture, yet is 38^{mm} long. The original length was at least 8^{mm} more. At the largest end the 3 wide faces are each 7^{mm} wide and the narrow faces are each 1·5^{mm} wide. At the small end the wide faces are 2·5^{mm} wide and the narrow faces are reduced to practically nothing, thus showing that in young stages the shell was really triangular.

Locality.—The type specimen, which is in the writer's collection, was found in the upper part of the Chazy, on the southeast point of Valcour Island (Cystid Point). It also occurs near Smuggler's Bay, in layers a little lower in the formation.

OSTRACODA.

Leperditia limatula sp. nov.

Length 10·5^{mm}; height 7·5^{mm}.
Length 9^{mm}; height 6^{mm}.
Length 9·5^{mm}; height 6.25^{mm}.
Length 9.5^{mm}; height 7·5^{mm}.

Shell of medium size, a little smaller than *Leperditia fabulites*, oblong in outline, higher behind than in front. Hinge short, straight. Anterior end regularly rounded. The posterior end slopes back almost straight for a short distance, but is broadly rounded on the lower posterior margin. The eye tubercle is small, on some specimens sharp, on others obscure. It is situated in the anterior angle, above and a little in front of the "muscle spot." The latter is large, circular, and very finely reticulated. Back of the muscle spot is a region of the shell which is covered with fine raised lines radiating from the side of the spot. These lines frequently anastomose, making a very pretty reticulate surface. The muscle spot is raised above the general surface of the carapace on the lower posterior side, where these lines originate, but the upper and anterior sides are level with the main part of the shell.

The right valve overlaps the left valve considerably, especially along the ventral edge, which is abruptly deflected and usually shows a low short ridge right at the keel. The lower margins of the anterior and posterior ends are flanged. The border is very narrow and is marked by small pits, which increase in size ventrally. On one finely preserved specimen the anterior flange shows 8 pits, of which the seventh, counted from the front, is largest, and the eighth is very small. On the posterior flange of the same specimen there are 10 pits, the eighth from the posterior end being the largest, the ninth a little smaller, and the tenth minute. The left valve is not so high in proportion to the length as the right valve, but it is also abruptly deflected ventrally. It shows neither anterior nor posterior flanges and there is a small projection close to the hinge line and parallel to it. Below this is a slight depression.

Locality.—Common on Valcour Island in certain localities. Rare at Valcour and Chazy, New York.

Primitia latimarginata sp. nov.

Carapace small and depressed. Front and posterior margins meet the dorsal margin at angles of little more than 90°. Both ends are broadly rounded, the ventral margin is gently curved. The shell is a little higher at the posterior end than

in front. There is a deep sulcus just in front of the middle, which starts from the dorsal margin and extends half-way down the valve, turning a little forward at the lower end. On well-preserved specimens, in front of this sulcus there is a prominent eye spot, which is sometimes translucent. Often there is another slight depression or sulcus in front of the eye spot. The border is wide, concave, and of nearly uniform width all around from the anterior angle of the dorsal margin to the posterior one. The test is frequently punctate.

Locality.—Common all through the Chazy limestone at Chazy, Valcour Island, Crown Point, and elsewhere in the Champlain Valley.

TRILOBITA.

Heliomera subgen. nov.

Heliomera sol (Billings).

Cheirurus sol Billings, 1865, Paleozoic Fossils of Canada, vol. i, p. 288, fig. 276.

Cephalon short, wide, the glabella very large and flattened, the cheeks small. Glabella almost semi-circular, with 3 pairs of long, narrow glabellar furrows, all of which turn backward on their inner ends, each joining the one back of it, and the third pair joining the neck furrow, thus producing a central lobe like that of *Amphilichas*. This central lobe is of uniform width up to the inner ends of the first pair of glabellar furrows, but turns outward in front of that point. Toward the front of this median lobe there is a slight depression, somewhat similar to that sometimes seen in *Pliomerops canadensis*. The first pair of glabellar furrows run backward at an angle of about 45°, the second pair at a smaller angle, while the third pair are nearly parallel to the neck furrow. The glabellar lobes are narrow and club-shaped. This radiating arrangement of the glabellar furrows and lobes probably suggested the specific name. The neck ring is wide, flat, and separated from the glabella by a deep furrow, which extends the whole width of the cephalon. The cheeks are not sufficiently well preserved to be described, but enough of the test remains to show that the outline of the cephalon was the same as in *Pseudosphærexochus vulcanus*. There is a narrow smooth border all around the front of the cephalon, and the surface is covered with fine tubercles. The relations of this species are rather doubtful. From the form of the cephalon it evidently belongs close to *Pseudosphærexochus*, but there has not been seen in species of that genus any tendency to vary in the direction of an isolated central lobe and long isolated glabellar

furrows. The glabellar furrows in the various species of *Pseudosphærexochus* are usually faint, never deeply impressed as in this species. In this last character and in the presence of the median depression of the glabella, it recalls *Pliomerops*. The glabella is much larger in proportion to the size of the cephalon in *Heliomera sol*, however, and it is probable that this form must be regarded as intermediate between the two genera. For trilobites with this type of glabellar structure the subgeneric name *Heliomera* is suggested.

Locality.—From the Raphistoma layers in the upper part of the Lower Chazy, at Chazy, New York. The type is in the Yale University Museum.

Paleontological Laboratory,
Yale University Museum, June 24, 1905.

Art. XXXIX.—*The Mechanical Properties of Catgut Musical Strings;* by J. R. Benton, Ph.D.

The experiments here described were made in connection with investigations on the stress-strain relation in elastic solids, carried out at the Geophysical Laboratory of the Carnegie Institution under the direction of Dr. G. F. Becker, to whom the writer desires to make acknowledgment for many valuable suggestions in regard to the work presented in this note. Researches on the stress-strain relation have been made for rubber and for the metals; and it was thought of interest to experiment also on a substance of intermediate properties as regards extension within the elastic limit; for this purpose, catgut, as used for strings of musical instruments, appeared to be best adapted. Owing to its hygroscopic properties and the complicated nature of the after-effects it exhibits, it was found that a precise determination of the deviations from Hooke's law would involve an amount of labor far greater than was thought to be warranted by the importance of the substance. Such results as were obtained, however, together with general data on the mechanical properties of catgut, seem of sufficient interest to justify the publication of the present note.

Tensile Strength.—A piece of catgut ·061^{cm} in diameter had an average breaking load of 12·0 kg., corresponding to a tensile strength of 43 kg. per mm^2 (60,000 lbs. per sq. in.). A piece ·038^{cm} in diameter broke under 4·5 kg., corresponding to a tensile strength of 41 kg. per mm^2. These figures show that it is nearly as strong as copper wire, and must be classed as one of the strongest organic substances, far exceeding all kinds of wood (less than 20,000 lbs. per sq. in.), leather (5000 lbs. per sq. in.), and hemp ropes (15,000 lbs. per sq. in.).

Catgut musical strings, as furnished on the market, are twisted, and tend to untwist when subjected to tension, and to twist up again when tension is removed. In order to study their elasticity, this twist must be removed, which is accomplished by soaking the string in water. If hot water is used the string becomes very soft, and contracts greatly in length. In this condition it behaves very much like rubber; it can be stretched to nearly double its unstrained length, and when released it snaps back like a rubber band.

It is greatly weakened, however, by being wet; but it regains its strength more or less completely upon drying, as shown in the following table:

Catgut string, ·038^{cm} in diameter.
Average breaking load before special treatment, 4·5 kg.

Number of tests.	Treatment.	Breaking load in kgs.
2	Soaked ½ hr. in water at 30° C., then tested while wet	2·1
1	" " " " " dried, then tested	5·0
2	Soaked 1 hr. in water at 30° C., dried for five days, then tested	4·3, 4·4
1	Soaked 5 min. in water at 90° C., then tested while wet	less than 0·5
4	" " " " " dried, then tested	1·0–1·9

Elongation at Rupture.—A piece 0·062^{cm} in diameter, and 5·9^{cm} long, stretched to 7·0^{cm} just before rupture, or 19 per cent of its original length. Another test gave 15 per cent. These figures include whatever stretching was due to untwisting. After rupture the pieces were too much frayed out for any determination of their length.

Specific gravity.—By weighing a piece of catgut (not treated with water) of known length and cross section, its specific gravity was determined as 1·18 (±0·01).

All the remaining experiments to be described were made on a violin E-string, 150^{cm} long and 0·062^{cm} in mean diameter (the diameter was not quite uniform, varying between 0·059 and 0·65). It was freed from its original torsion on August 20, 1904, by soaking one and a half hours in water of 30° C., and while drying it supported a load of 0·5 kg. The experiments were carried on from time to time during the following year, at intervals during the prosecution of other work.

Hygroscopic properties.—Upon setting up this string and sighting with a micrometer telescope at a point near its lower end, it was at once seen that the length of the string did not remain constant; and by observing at intervals and determining the humidity of the air at the same time, it was easily demonstrated that the string stretched when the dampness increased and contracted when it decreased. This is in accordance with the well-known tendency of violin strings to break in dry weather. When the weather is damp the string has to be tightened to maintain the tension to keep it in tune; with increasing dryness its tension increases until finally it snaps. The actual tension required on a violin E-string to produce the proper pitch of 640 vibrations per second may be computed from the length of string (about 33^{cm}) and its specific mass

(0·0035 g. per cm. of length) by the well-known formula for transverse vibrations of strings, and comes out about 6 kg., or about one-half of the breaking load. During the above experiments the string carried a load of 1·0 kg, and the temperature was 20 to 25° C. The order of magnitude of the changes was 0·0002 of the length of the string for each cm. of mercury of vapor tension. Precise determination of the dependence of length on humidity was made prohibitively difficult by the phenomena described in the following paragraph.

After-effects.—Whenever any change was produced in the conditions, the catgut did not at once come into equilibrium under the new conditions, but did so only gradually. Thus,

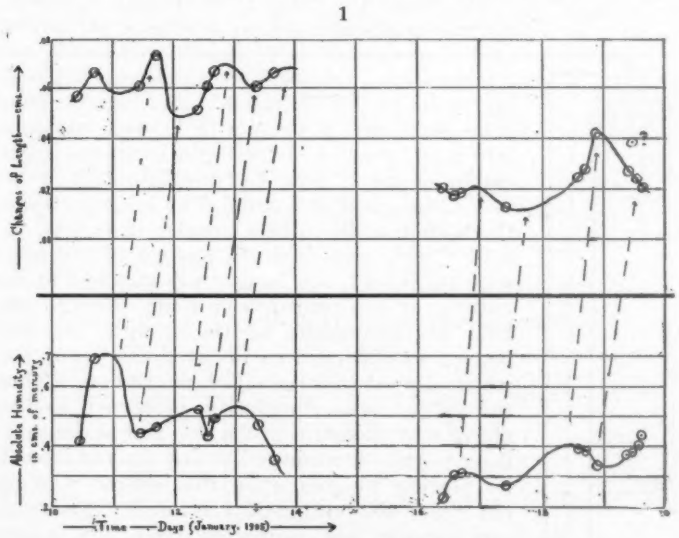


FIGURE 1.—Length and Humidity as Functions of Time.

when the load upon it was changed, it exhibited in marked degree the well-known elastic after-effect, requiring some days to come to sensible equilibrium, during which time the change in length due to change in load increased by about 25 per cent of its final amount. It was found also that the stretch due to humidity tended to continue after a change of humidity ceased; this could easily be seen in the fluctuations of humidity accompanying changes of weather; but no facilities for controlling humidity were available, and so no attempt could be made to study these phenomena thoroughly. No doubt some time is required for moisture to penetrate into the interior of the catgut. The curves of figure 1 represent change of length of the

catgut, and humidity (absolute), both as functions of time. After-effects were detected also in connection with change of temperature.

The elastic after-effect is of course responsible for the behavior of new strings on violins, which get out of tune very rapidly at first, and always in the direction of lower pitch. With greater duration of the tension the after-effect becomes less marked and the material approaches equilibrium under the imposed conditions. But if left for some time, the tendency is always towards lower rather than higher pitch, if temperature and humidity do not change.

To protect the string from changes of humidity, it was placed inside of a tube of galvanized iron ("spout-pipe"), 6 inches in diameter, and 2 meters long, the seam of which was soldered up (*k*, fig. 2). Near the top and bottom, plate glass windows (*b*, *b*), $7\frac{1}{2}\times15^{cm}$, were fastened into it and made moisture-tight by liberal application of thick grease ("mobilubricant") beneath the glass and around its edges. Inside the bottom of the tube a circular trough (*o*, fig. 2) 4^{cm} wide was soldered against it and filled with engine oil. A hanger was attached to the bottom of the catgut, and hung through the hole in the middle of the trough; to this hanger was fastened an inverted cup (*a*) of tin, which dipped into the oil of the trough. Thus the catgut was completely protected against changes of moisture in the air, and at the same time could be subjected to any desired tension by placing weights upon the hanger sticking out from the bottom of the tube. The whole arrangement was supported from the ceiling and braced against the floor. Micrometer telescopes for reading at top and bottom were supported from the tube itself. The top telescope took account of any sinking of the upper support; the distance between the two marks sighted upon on the string was 138^{cm}. The telescope at the bottom could be shifted bodily to keep up with stretching of the string; a reflection prism was fastened to it in front of its objective, and reflected into its field of view the image of a steel centimeter scale fastened vertically near by. In this way the shift of the telescope when moved could be measured.

Coefficient of Thermal Expansion.—After the catgut had been in the tube four days, readings were made upon it from

time to time, and were still found to fluctuate. Upon comparing these readings with those for temperature, it was obvious that the changes were related to it, as may be seen in figure 3;

3

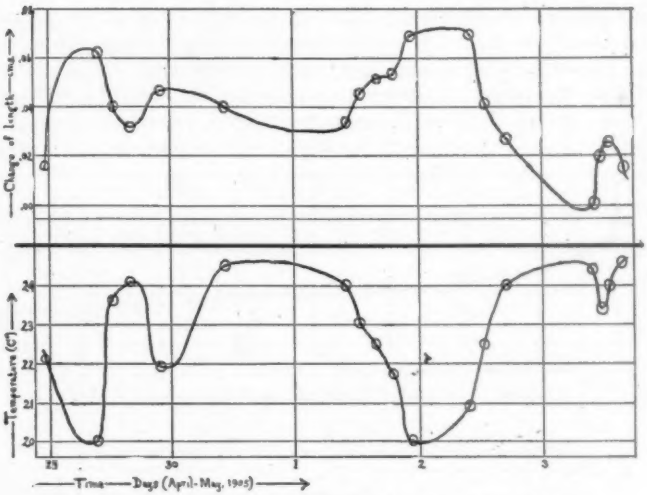


FIGURE 3.—Temperature and Length as Functions of Time.

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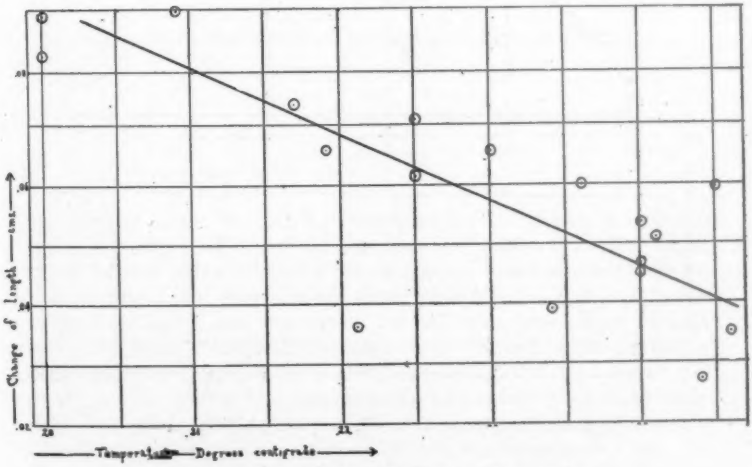

FIGURE 4.—Dependence of Length on Temperature.

but again the state of affairs is complicated by after-effects. These were simply neglected, however, and equations were set up for the determination of the coefficient of expansion, using eighteen observations; solving them by the method of least squares, the coefficient of linear expansion came out $-0{\cdot}000081$ per degree centigrade. The observations used are shown graphically in figure 4. As the coefficient of expansion comes out *negative* and larger in absolute value than for most substances, the question arises whether the data obtained were not

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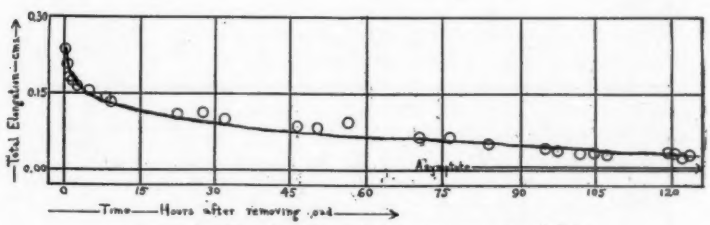

FIGURE 5.—Elastic After-effect upon removing 0·5 kg.

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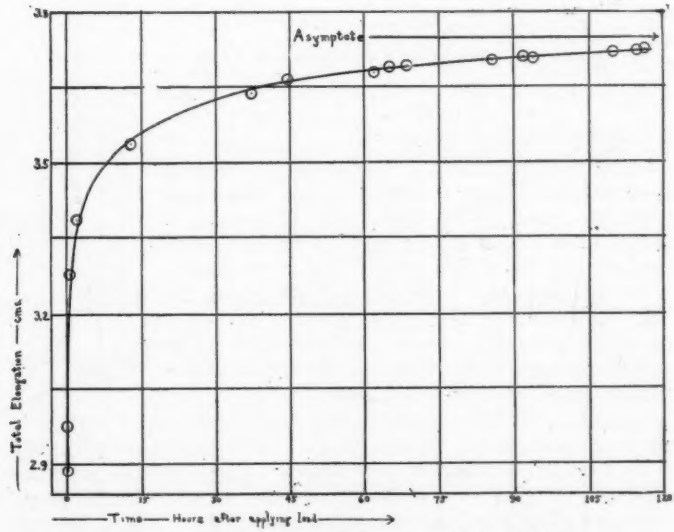

FIGURE 6.—Elastic After-effect upon applying 2·5 kgs.

influenced by humidity. In the enclosure containing the catgut, the *absolute* humidity was constant, but the *relative* humidity increased as the temperature fell; and it may be that under such conditions the material tends to absorb moisture and thus increase in length. It is possible, therefore, that in a perfectly dry atmosphere, the behavior of catgut under varying temperature might be quite different.

Elasticity.—To get at the true elastic properties of the material it would be necessary, after each change of load, to wait until the disappearance of the after-effect before determining the corresponding length of the string. In strictness,

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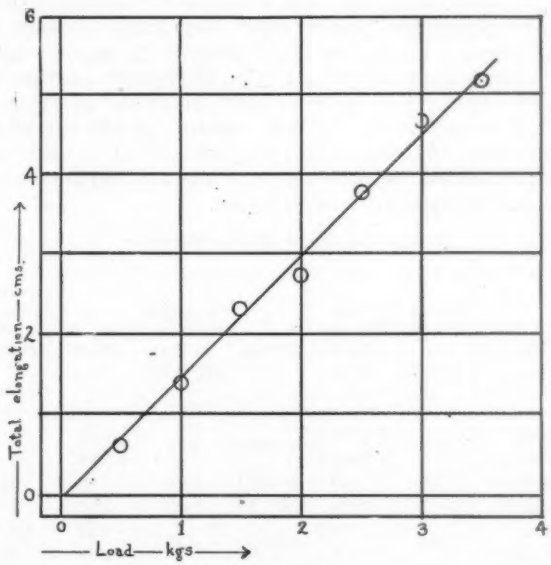

an infinite time would be requisite for this; but practically the following procedure can be adopted, and was employed in these experiments: After each change of load, observations on the length of the string were made at intervals of a few hours for several days, and corrected for thermal expansion. From the data thus obtained, a curve was plotted with times for abscissas and lengths for ordinates; and from this curve the final length which the string tended to reach with disappearing after-effect, was estimated. Of course such an estimation involves considerable uncertainty and arbitrariness; but no other course seems available, as long as experiments must be

limited to finite time. Two of the curves obtained in this manner are exhibited in figures 5 and 6, together with their asymptotes as estimated. Such curves were taken after each change of load; but it is not thought to be of any interest here to submit more than two of them, or to present tables of the numerical data from which the curves are plotted.

The results obtained in this manner are summarized in the accompanying table. After any load had acted for a few days it was removed, and the string left unloaded a few days before the next load was applied. The individual readings were made to thousandths of centimeters; but the estimation of the length to which the string tended at infinite time was carried out only to hundredths. The first column of the table gives the loads, in kilograms, placed upon the hanger, which itself weighed about 0·5 kg.; the third column gives the total elongation after disappearance of the after-effect, estimated as explained above; the sixth column gives the after-effect, of change of strain from the first instant (practically about 60 seconds) after applying the load until final equilibrium is reached, expressed as percentage of the total final strain; the other columns require no explanation.

Violin E-string, 0·062^{cm} in diameter.

Load, in kgs.	Stress in kgs. per mm^2.	Total elongation in cms.	Strain.	Young's modulus in kgs. per mm^2.	After-effect.	Time the load acted, in days.	Mean temperature, ° C.
0·5 (applied)	1·66	0·59	0·0044	378	30%	5	24
0·5 (removed)		0·62			33%	5	24
1·0 (applied)	3·31	1·39	0·0101	328	44%	6	24
1·5 (removed)	4·97	2·26	0·0164	303	26%	5	25
2·0 (applied)	6·63	2·70	0·0198	335	22%	4	28
2·0 (removed)		2·75			29%	7	29
2·5 (applied)	8·29	3·78	0·0272	304	22%	5	31
2·5 (removed)		3·73			29%	4	28
3·0 (applied)	9·95	4·66	0·0338	294	20%	8	27
3·5 (applied)	11·60	5·17	0·0375	310	15%	6	28

*Young's Modulus.**—The mean value of Young's modulus from these experiments comes out 322 kgs. per mm^2, or 458,000

* The values of Young's modulus given in the above table are obtained by direct division of each stress by the corresponding strain. In strictness, Young's modulus should be determined from the slope of the stress-strain curve at the origin. But in the special case that the stress-strain curve is a straight line, the quotient of stress by strain for any point of the curve gives the same result as the slope at the origin. The data under discussion not being sufficiently regular to determine the true form of the stress-strain curve, it is taken as a straight line within the limits of the experiments; and this justifies the above method of determining Young's modulus.

lbs. per sq. in. If observations taken immediately after applying the loads had been used, instead of those after the disappearance of the after-effect, we would have about 400 kg. per mm^2 for Young's modulus; and this latter figure represents the elastic resistance of the material to a stress applied for a short time, as in longitudinal vibrations of the string.

Limit of Elasticity.—As is seen from the table, slight permanent set appears, though not with great certainty, after applying 2·5 kg (+0·5 kg. for the hanger). That makes the limit of elasticity about 8 kg. per mm^2, corresponding to a strain of 2·7 per cent.

Stress-strain Relation.—The results tabulated above are shown graphically in figure 7. It is clear from it that Hooke's law is *approximately* true; but the results obtained are too irregular to furnish ground for any definite statement as to deviations from Hooke's law.

Sewickley, Penn.

ART. XL.—*The Use of the Rotating Cathode for the Estimation of Cadmium taken as the Chloride;* by CHARLES P. FLORA.

[Contributions from the Kent Chemical Laboratory of Yale Univ.—cxl.]

IN a previous paper* the author has described the use of the rotating cathode for the estimation of cadmium taken as the sulphate. In the present paper a simular study has been made of the behavior of cadmium when taken in the form of the chloride. Some differences are to be expected, since it has been established with some certainty that cadmium chloride, when subjected to electrolysis, forms not only positive cadmium ions and negative chlorine ions, but also complex cadmium-chlorine negative ions; and, in addition, the chlorine, when set free, does not recombine with the water, to set free oxygen, but exists in the solution in its free state. That there are some very important differences a few qualitative experiments showed, so that the study of the estimation of cadmium when taken in the form of this salt was now undertaken.

A solution was made up to a convenient strength, and the standard determined by the mean of several closely agreeing determinations by the carbonate method, which the author had carefully tested and found to be perfectly reliable. This showed 0·1589 grm. of cadmium in 30^{cm^3} of the solution, or 0·0052966 grm. per cubic centimeter.

I. *In Solutions containing Sulphuric Acid.*

The procedure with cadmium chloride was the same as with the cadmium sulphate, and the results were very satisfactory. But emphasis is to be laid upon the dilution in this case especially, for it was found that from the more dilute solution it is almost impossible to drive the last traces of cadmium. A dilution of 45^{cm^3} was found to give the most satisfactory results. To this solution ten drops of sulphuric acid of 1:4 dilution were added before electrolysis. The following results were obtained under these conditions:

No.	Cd. grm.	Cur't = amp.	N. D_{100} amp.	E.M.F. vts.	Time. min.	Cd. fd. grm.	Error. grm.
1.	0·1059	1·0–1·5	3·0–4·5	6·5–7·8	25	0·1054	—0·0005
1.	0·1059	2·0–3·0	6·0–9·0	7·8	15	0·1058	—0·0001

II. *In Solutions containing Acetates.*

The acetate method has proved one of the most satisfactory for the estimation of cadmium sulphate, but strangely enough,

* This Journal, xx, 268 (1905).

it was found to be absolutely unfitted for the estimation of cadmium when taken as the chloride. The deposited metal was always spongy, often non-adherent and unfitted for quantitative work. The sponginess was less marked when no potassium sulphate was present, but the metal was still poorly adherent and unweighable. The modifications tried are given for the sake of comparison in the following table. The current potential throughout was 7·8 volts, while the dilution, excepting in experiment No. 4, was 45$^{cm^3}$. In No. 4 a dilution of 65$^{cm^3}$ was tried, but it offered no apparent advantage.

No.	Cd. grm.	$NaOC_2H_3O$. grm.	K_2SO_4. grm.	Cur't = amp.	N. D_{100} amp.	Time. min.	Notes.
1.	0·1324	1·5	0·5	1·5	4·5	13	very spongy
2.	0·1324	1·5	none	1·0	3·0	8	0·1314 grm. fd.
3.	0·1059	1·0	"	0·75	2·25	20	non-adherent.
4.	0·1059	1·5	0·5	1·5	4·5	—	spongy, non-adherent
5.	0·1059	1·5	none	1·0	3·0	—	2$^{cm^3}$ formalin added, spongy
6.	0·1059	1·5	"	0·75	2·25	—	non-adht., cryst.
7.	0·1059	0·5	0·5	1·0	3·0	—	" "

III. *In Solutions containing Cyanides.*

The use of a cyanide solution gave results with the chloride of cadmium as satisfactory as were given when the sulphate of cadmium was taken. As in that case, care must be taken to avoid foaming of the solution. The best dilution seemed to be 65$^{cm^3}$. The time required is a trifle longer than in the estimation of cadmium sulphate by this method. The following results were obtained:

No.	Cd. grm.	KCN. grm.	NaOH. grm.	Cur't = amp.	N. D_{100} amp.	E.M.F. vts.	Time. min.	Cd. fd. grm.	Error. grm.
1.	0·1324	1·5	1·0	4	12	7·8	35	0·1322	−0·0002
2.	0·1324	1·5	1·0	4	12	7·8	40	0·1317	−0·0007

In experiment No. 2 there was much foaming, and a trace of cadmium remained in solution, the deposition being much retarded.

IV. *In Solutions containing Pyrophosphates.*

The different modifications of the pyrophosphate method gave results which were quite satisfactory, and in every respect comparable with the results obtained with this electrolyte in the estimation of cadmium sulphate. As was the case with that salt, the use of ammonium hydroxide to dissolve the precipitate gave the most satisfactory results; while after that, sulphuric acid seemed to be the most suitable

solvent. The deposits obtained from solutions to which were added free phosphoric acid showed a slight tendency toward sponginess. When hydrochloric acid was added, the deposits were good but deposition was slow. The total volume in each case was 45$^{cm^3}$; the amount of sodium pyrophosphate used was 9·5 grm.; while the current potential was 7·8 volts.

The following results were obtained:

No.	Cd. grm.	Solvent.	Cur't = amp.	N. D_{100}. amp.	Time. min.	Cd. fd. grm.	Error. grm.
1.	0·1324	NH_4OH, conc., 1$^{cm^3}$.	0·5	1·5	15	0·1327	+0·0003
2.	0·1324	H_2SO_4 (1·4), 12 dps.	0·75	2·25	35	0·1328	+0·0004
3.	0·1342	H_3PO_4 (sp. gr. 1·7), 15 dps.	0·75–1·0	2·25–3·0	30	0·1331	+0·0007
4.	0·1324	HCl, 1 : 4, 15 dps.	0·7 –0·5	2·1– 1·5	45	0·1319	—0·0005

V. *In Solutions containing Phosphates.*

With cadmium chloride, hydrogen disodic phosphate must be used with even more care than with cadmium sulphate, if deposits which are even slightly satisfactory are to be obtained; and even when used with caution, the tendency to form spongy deposits is so persistent that this method is not to be recommended where other methods are available. The following are the solutions tried, the concentration being 45$^{cm^3}$ throughout:

No.	Cd. grm.	HNa_2PO_4. grm.	H_3PO_4. (sp. gr.-1·7)	Cur't = amp.	N. D_{100}. amp.	E.M.F. vts.	Time. min.	Cd. fd. grm.	Error grm.
1.	0·1059	0·25	5$^{cm^3}$	2·0–3·0	6·0–9·0	7·8	15	0·1082	+0·0023
2.	0·1324	0·25	2·5$^{cm^3}$	2·0–3·0	6·0–9·0	7·8	13	0·1344	+0·0020
3.	0·1324	0·20	10 dps	1·0	3·0	7·8	15	0·1330	+0·0006
4.	0·1324	0·20	6 dps	0·25	0·75	7·8	35	0·1310	—0·0014

Numbers 1 and 2 gave spongy deposits; number 4 showed no color upon testing the solution at the end of the operation with hydrogen sulphide, but this test does not seem to be very sensitive in this solution. Number 3 seems to represent the best conditions.

VI. *In Solutions containing Oxalates.*

Several qualitative tests, using conditions identical with those giving the least unsatisfactory deposits with cadmium sulphate, were tried upon the cadmium chloride, with like unsatisfactory results, so that the work upon the oxalate method was not pursued further.

VII. *In Solutions containing Urea, etc.*

A few qualitative tests seemed to indicate that solutions containing urea, formaldehyde or acetaldehyde would furnish very satisfactory media for the estimation of cadmium, taken in the form of the chloride, but further experimentation proved these appearances to be deceptive. Under these conditions,

the cadmium is deposited much more quickly from a solution of its chloride than of the sulphate, and the deposit in the earlier part of the precipitation appears to be very satisfactory. But the chlorine set free apparently has some action upon the organic compound present to produce substances detrimental to the process. With care, however, satisfactory results may be obtained, as may be seen from a study of the following tables:

SERIES A.—UREA.

No.	Cd. grm.	Urea. grm.	Cur't = amp.	$N.D_{100}$. amp.	E.M.F. vts.	Time. min.	Tot. vol. cm^3.	Cd. fd. grm.	Error. grm.	Notes.
1.	0·1324	3	1·0	3·0	12	20	60	0·1312	−0·0012	spongy, not all out
2.	0·1324	2	1·0	3·0	12	30	60	0·1336	+0·0012	spongy, not all out
3.	0·1324	3	1·0	3·0	7·8	15	55	0·1342	+0·0018	very spongy, all out
4.	0·1324	2	0·25	0·75	7·8	25	60	0·1324	±0·0000	all out
5.	0·1324	2	0·5	1·5	12	20	60	0·1333	+0·0009	slt. spy. all out
6.	0·1324	1	1·0	3·0	12	20	60	0·1370	+0·0046	very spongy
7.	0·1324	1·5	0·25–0·5	0·75–1·5	7·8	30	60	0·1328	+0·0004	good
8.	0·1324	1·5	0·25–0·5	0·75–1·5	7·8	30	60	0·1329	+0·0005	fair

The amount of urea present, therefore, should be between 1·5 grm. and 2 grms., and the current potential should not exceed 8 volts, instead of the 12 volts permissible when cadmium sulphate was used. The test with hydrogen sulphide does not seem to be very delicate in this solution, so that at least 30 minutes should be allowed for each determination. Some writers recommend the testing of the end-point in similar cases by raising the level of the liquid upon the cathode, but this was not proved of much value in this work, as the amount of metal deposited upon the fresh cathode surface from the solutions near the end of the process is imperceptible.

A solution to which formaldehyde was added gave the following results:

SERIES B.—FORMALDEHYDE (FORMALIN).

No.	Cd. grm.	Form. cm^3.	Cur't = amp.	$N.D_{100}$. amp.	E.M.F. vts.	Time. min.	Tol. vol. cm^3.	Cd. fd. grm.	Error. grm.	Notes.
1.	0·1324	3·0	0·25–1·5	0·75–4·5	7·8	20	45	0·1333	+0·0009	fair
2.	0·1324	2·0	0·50–2·0	1·50–6·0	11·8	15	45	0·1330	+0·0006	slt. spgy
3.	0·1324	1·5	0·75	2·25	7·8	30	60	0·1324	±0·0000	compact
4.	0·1324	1·5	1·0	3·0	7·8	35	60	0·1325	+0·0001	"

It will be seen from these results that it is better to use a somewhat smaller quantity of formaldehyde than was used with the cadmium sulphate; the current potential should not exceed 8 volts; while the solution should be rather dilute (60^{cm^3}).

These cautions are of even greater importance when acetaldehyde is used, if satisfactory results are to be obtained, as the following results show:

SERIES C.—ACETALDEHYDE (95%).

No.	Cd. grm.	Aldehd. (95%) cm^3.	Cur't = amp.	$N.D_{100}$. amp.	E.M.F. vts.	Time. min.	Tot. vol. cm^3.	Cd. fd. grm.	Error. grm.	Notes.
1.	0·1324	2·0	0·2–0·7	0·6–2·1	7·8	30	60	0·1311	−0·0013	not all out slt. spgy
2.	0·1324	1·5	0·2–0·75	0·6–2·25	7·8	30	60	0·1346	+0·0022	spongy
3.	0·1324	0·5	0·2–1·0	0·6–3·0	7·8	65	60	0·1307	−0·0017	spongy, not all out
4.	0·1324	1·0	0·1–0·75	0·3–2·25	8·0	35	60	0·1328	−0·0001	fair

VIII. *In Solutions containing Formates and Tartrates.*

Like cadmium sulphate, so also cadmium chloride gave negative results when solutions containing in addition potassium formate in the presence of formic acid were subjected to electrolysis. Moreover, when no formate was added, but formic acid alone, the results were still unsatisfactory. To solutions containing 0·1324 grm. of cadmium in the form of the chloride was added $1·5^{cm^3}$ of formic acid, the whole diluted to 50^{cm^3}, and electrolysis conducted under potentials of 7·5 and 11·8 volts. In each case the precipitate was spongy and non-adherent, while the solution persistently held traces of cadmium, even after subjecting to the current nearly two hours.

Solutions containing tartaric acid behaved in a similar manner. In the presence of 3 grm. of tartaric acid, under current tensions of 8 and 12 volts, the precipitated metal peeled from the cathode during revolution, the deposit was spongy, and deposition seemed to be complete at no point of the operation.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *The Formation of Ozone by Ultra-violet Light.*—Fischer and Braemer, by employing a mercury-vapor lamp with quartz walls, have studied the effect of ultra-violet light upon oxygen. They have found that ozonization takes place if the temperature is not too high, for above 270° ozone is decomposed more rapidly than it is formed. Thorough cooling of the oxygen by means of a water-jacket increased the yield of ozone, while a greater intensity of the light of the lamp also increased the yield to a certain limit and then decreased it, probably on account of the effect of greater heating. Upon doubling the speed of the oxygen through the apparatus the total amount of ozone formed was nearly doubled, but the percentage of ozone formed was somewhat diminished. The authors believe that their experiments show the correctness of Warburg's view, that the formation of ozone by the silent electric discharge is due to the ultra-violet light thus formed. A short time ago one of the authors found that their lamp could produce in a few hours the violet coloration of glass containing manganese, which is effected by sunlight in high mountainous regions in months or years, and in our low regions only after longer periods, because the ultra-violet part of its spectrum is strongly absorbed by the earth's atmosphere. By this absorption of ultra-violet sunlight by our atmosphere ozone results in the upper layers of air, and when it sinks to lower regions it is decomposed by oxidizable substances.—*Berichte*, xxxviii, 2633. H. L. W.

2. *A New Reagent for Nickel.*—Heretofore there has been no characteristic and delicate reaction for nickel, particularly in the presence of considerable amounts of cobalt. The most delicate of the known tests is probably the brown color produced by alkali thiocarbonates, but this is interfered with by the presence of cobalt. Tschugaeff has recently found that α-dimethylglyoxime,

$$CH_3 . C(: N . OH) . C(: N . OH) . CH_3,$$

is an extraordinarily delicate and characteristic reagent for the metal under consideration. To make the test, the solution is first freed from any excess of acid by the addition of alkali (preferably an excess of ammonia or sodium acetate solution), then some powdered dioxime is added and the solution is heated to boiling for a short time. If the solution is not exceedingly dilute, a scarlet precipitate is produced at once having the composition $NiD . DH_2$, where DH_2 represents dioxime. When very small amounts of nickel are present a yellowish liquid is obtained, from which, after cooling, the red precipitate is deposited after a few minutes, whereby the excess of dioxime which separates at

the same time is colored distinctly pink. The delicacy of this reaction is so great that it is very distinct in solutions containing only one part of nickel to 400,000 parts of water. The reaction is not at all masked by the presence of ten times as much cobalt as nickel, but since cobalt salts also react with the dimethylglyoxime with the formation of a brown compound, it is expedient to modify the process when much cobalt is present by adding a very large excess of ammonia to the liquid, then shaking repeatedly in order to oxidize the cobalt to complex cobalticammonia compounds, and then proceeding as before. In this case, with not too minute amounts of nickel, the reaction appears at once, when the liquid is boiled, by the formation of a scarlet froth which rises upon the walls of the test-tube, but generally it is necessary to filter the cooled liquid and to wash the residue with water in order to detect its pink color. The author gives a method for preparing the new reagent, and states that it may be obtained commercially from Kahlbaum.—*Berichte*, xxxviii, 2520.

H. L. W.

3. *The Electrolytic Dissociation Theory with some of its Applications;* by HENRY P. TALBOT and ARTHUR A. BLANCHARD, 8vo, pp. 84. New York, 1905 (The Macmillan Co.).—This is an elementary treatise for the use of students of chemistry. It deals with the fundamental topics of physical chemistry in a very clear and simple manner, and it is undoubtedly a valuable text-book for students who are not far enough advanced to take up the subject more elaborately. The six chapters of the book have the following titles: "Evidences of Electrolytic Dissociation afforded by a Study of the Properties of Solutions," "The Law of Mass Action and the Chemical Behavior of Electrolytes," "Electrolytic Solution Pressure," "Oxidation and Reduction," "The More Common Ions and their Characteristics," "Experiments."

H. L. W.

4. *Soils and Fertilizers;* by HARRY SCHNEIDER, 8vo, pp. 294. Easton, Pa., 1905 (The Chemical Publishing Co.).—This book gives in condensed form the principles of chemistry which have a bearing upon the conservation of soil fertility and the economic use of fertilizers. While it is intended particularly as a text-book for students in agricultural colleges, and includes a course of laboratory experiments for such students, it presents the subject in such a practical manner that it should find extensive use among farmers. The present second edition has been entirely rewritten, and has received the addition of new material.

H. L. W.

5. *Engineering Chemistry;* by THOMAS B. STILLMAN, Third Edition, 8vo, pp. 597. Easton, Pa., 1905 (The Chemical Publishing Co.).—The third edition of this well-known work on technical analysis contains much new matter, especially in regard to asphalts, lubricating-oils, Portland cement, and the technology of the products of the blast-furnace. In its present form the book will be more useful than ever to those who are interested in commercial chemistry.

H. L. W.

6. *A Text-Book of Chemical Arithmetic;* by H. L. WELLS, 12mo, pp. 169, 1905. New York (John Wiley & Sons).—Every instructor in chemistry knows how difficult it is to induce students to use their reasoning powers in solving simple problems. The tendency is always to use a formula or a factor without knowing or caring what these may mean. This text-book is designed to teach chemical arithmetic, but on a basis of reason rather than rules. Part I on approximate numbers deals with calculations from measurements involving errors of observation. The abbreviated methods of multiplication and division are also given. The rest of the book deals with chemical calculations relating to weights, to gases, and to volumetric analysis. Throughout the book, a large number of very practical problems is given. A student who has once solved these problems intelligently should certainly have no further trouble with chemical calculations. In an appendix, several convenient tables are given, including a table of logarithms. H. W. F.

7. *A Text Book of Physiological Chemistry for Students of Medicine;* by JOHN H. LONG, Professor of Chemistry in Northwestern University Medical School, Chicago. Pp. viii + 424. Illustrated. Philadelphia, 1905 (P. Blakiston's Son).—In this volume are presented in a clear and simple form the necessary facts and principles underlying the science of physiological chemistry, written for use by students in medical schools, but few references are made to the literature. Besides the general topics usually treated of in a book of this character there is given an outline of the chemical phases of recent theories of immunity together with explanations of the application of the methods of cryoscopy and electrical conductivity and other physical processes in the field of chemistry related to medicine. The book is well adapted to the purpose for which it was written and should be well received. F. P. UNDERHILL.

8. *Formation of Helium from the Radium Emanation.*—In answer to many inquiries called forth by an article on this subject, published in the Berichte d. naturf. Ges. Freiburg i Br. xvi, p. 222, 1904, F. HIMSTEDT and G. MEYER relate further experiments upon this subject. They have repeated their work with $RaBr_2$ and also with $BaBr_2$ by the same method. Using a much greater amount of material, they never found a trace of a helium line. They still possess, however, three tubes which show with the greatest ease the helium spectrum, which could not have come from the air of the room or from any source but the emanation.

In order to determine whether any occlusion phenomenon similar to the occlusion of hydrogen by palladium was concerned in the appearance of helium, they made the following experiments:

Palladium foil filled with hydrogen was placed in a quartz tube connected to a vacuum pump, and in the process of exhaustion was heated to a red heat and was flushed out with CO_2 until every trace of the hydrogen spectrum disappeared. After three

days, on heating, the hydrogen spectrum reappeared. After eight days, on repetition of the heating, the hydrogen lines again appeared. Further examination was prevented by the breaking of the tube.

The following experiment with cleveite led to a totally different result. In a combustion tube 0·3 g. of cleveite with SO_4KH was strongly heated and the tube flushed with hydrogen until no helium lines could be seen. The tube was then exhausted as far as possible. After three days, perhaps, there was a trace of the helium spectrum; but repeated heating and pumping disclosed in fourteen days no trace of helium. This experiment was repeated without SO_4KH with the same result.

In marked contrast to this experiment was the following: About 40 mg. $RaBr_2$ were so strongly heated in a highly exhausted quartz tube that the substance resublimed in a cooled end of the tube. The tube was flushed with hydrogen and exhausted, and on the following day the substance was again resublimed; no trace of the helium spectrum was seen. In six weeks, however, the helium spectrum could be readily produced in the tube. These experiments appear to the author to dispose of the theory of occlusion.

They point out that there may be a possibility of the formation of a helid. Instead of pure $RaBr_2$ we may be dealing with a mixture of this substance with a small quantity of a hypothetical helid. However this may be, they conclude that there is no doubt of a connection between the radium emanation and helium. —*Ann. der Physik*, No. 10, 1905, pp. 905–1008. J. T.

9. *Blondot's "Emission pesante."*—M. R. Blondot published in the Comptes Rendus issues of 1904 two papers on a phenomenon analogous to the so-called N-rays, to which he gave the name "emission pesante." A preparation of calcium sulphide becomes more luminescent under the influence of this emission. Blondlot states that he has not only observed this increase in luminescence, but also an effect of the magnetic field on the emission. Rudolf F. Pozdena has made an exhaustive examination of the effects claimed by Blondlot and cannot find any evidence of the new emission if the observer does not conduct the experiments himself. The phenomenon is a subjective one and may arise in the anatomy of the retina of the eye by a species of autosuggestion leading to a "Will to believe."—*Ann. der Physik*, No. 6, 1905, pp. 104–131. J. T.

10. *Diffusion of Nascent Hydrogen through Iron.* — A. Winkleman has conducted a long series of experiments upon this subject with the following conclusions:

The nascent hydrogen being formed on the outside of a hollow iron cylinder which was closed at the bottom and connected at the other end with an air pump, the iron cylinder serving as a cathode in a suitable electrolytic cell, it was found:

(1) The quantity of gas diffusing from the outside to the inside of the cylinder was independent of the pressure inside the cylin-

der over a range of 0 to 89^{cm} of mercury. The quantity, moreover, was not altered if the exterior pressure on the iron cylinder was varied from one to a half atmosphere. The pressure, therefore, under which the gas is driven through the iron is of a different nature from that which one might suppose and has an under limit of 58 atmospheres.

(2) The diffusion with constant current strength increases notably with the temperature; and if one puts the diffusion proportional to a power of the absolute temperature, this power is at least equal to 5.

(3) The diffusion increases at constant temperature with increasing current strength but not in a proportionate manner.

(4) From 1 and 3 one can understand the observations of Nernst which show that the pressure of the ions formed electrolytically can be very great and that this pressure depends upon the potential difference under which the electrolysis occurs. In view of this great pressure which drives the ions through the metal, one can understand the no effect on one to a half atmosphere mentioned in 1; also one does not wonder at the results of Bellanti and Lussana, who found that diffusion occurred even against a pressure of 20 atmospheres.

(5) At constant temperature and similar conditions of solutions and electrodes the quantity of diffusion was nearly proportional to the potential difference.—*Ann. der Physik*, No. 9, 1905, pp. 589–626. J. T.

11. *Landolt-Börnstein Physikalisch-chemische Tabellen.* Dritte umgearbeitete und vermehrte Auflage, herausgegeben von Dr. Richard Börnstein und Dr. Wilhelm Meyerhoffer. 861 pp. Berlin, 1905 (Julius Springer).—The first edition of this very important work was published in 1883 and the second in 1894. The decade that has passed since the latter date has seen a very high degree of activity in physical research and a corresponding increase in the amount of physical data. In the working over and arrangement of this large amount of material, the editors have had the support of upwards of forty associates, chiefly in Germany; the work has been carried through with the support of the Prussian Academy of Sciences. The volume opens with the international atomic weights of 1903 calculated with oxygen = 16. Then follow tables of latitude and longitude of important places and then the tables of physical data relating to volume, density, elasticity, tension, etc.; then those pertaining to heat, light, elasticity, magnetism and sound. The name of the worker who has elaborated each series of tables is given at the bottom of each page and following each subject are the references to the literature giving fully the authorities quoted. The comprehensive scope, thoroughness and accuracy of this great work give it a unique place in physical literature and make it essential to every laboratory.

II. Geology and Mineralogy.

1. *United States Geological Survey:* Charles D. Walcott, Director.—Recent publications of the U. S. Geological Survey are included in the following list. Notices are for the most part deferred till a later number.

Folios: No. 122.—Tahlequah Quadrangle, Indian Territory–Arkansas; by Joseph A. Taff.

No. 123.—Elders Ridge Quadrangle, Pennsylvania; by Ralph W. Stone.

No. 124.—Mount Mitchell Quadrangle, North Carolina–Tennessee; by Arthur Keith.

No. 125.—Rural Valley Quadrangle, Pennsylvania; by Charles Butts.

Monograph, No. XLVIII.—Status of the Mesozoic Floras of the United States. Second Paper; by Lester F. Ward, with the collaboration of William M. Fontaine, Arthur Bibbins and G. R. Wieland. Part I, Text, pp. 616. Part II, plates i–cxix.

Professional Papers: No. 34.—The Delavan Lobe of the Lake Michigan Glacier of the Wisconsin Stage of Glaciation and Associated Phenomena; by William C. Alden. Pp. 106, with 15 plates. See p. 409.

No. 36.—The Lead, Zinc and Fluorspar Deposits of Western Kentucky; by E. O. Ulrich and W. S. Tangier-Smith. Part I, Geology and General Relations by E. O. Ulrich. Pp. 1–105, plates i–vii. Part II, Ore Deposits and Mines by W. S. Tangier-Smith. Pp. 107–218, plates viii–xv, 31 text-figures.

No. 38.—Economic Geology of the Brigham Mining District, Utah; by John Mason Boutwell. With a Section on Areal Geology by Arthur Keith and an Introduction on General Geology by Samuel Franklin Emmons. Pp. 413, 49 plates, 10 figures.

Bulletins—No. 208.—Descriptive Geology of Nevada south of the Fortieth Parallel and Adjacent Portions of California; by Josiah Edward Spurr. Second edition. Pp. 229, 8 plates. Map in pocket.

No. 235.—A Geological Reconnaissance across the Cascade Range near the Forty-ninth parallel; by George Otis Smith and Frank C. Calkins. Pp. 103, 4 plates. It is found that "the Cascade Mountains near the forty-ninth parallel are composed in greater part of igneous rocks that belong mainly to great batholithic masses of rather acidic composition quite comparable (in volume) with the immense intrusions of the Sierra Nevada."

No. 237.—Petrography and Geology of the Igneous Rocks of Highwood Mountains, Montana; by Louis Valentine Pirsson. Pp. 208, 7 plates, 8 figures.

No. 245.—Results of Primary Triangulation and Primary Traverse, fiscal year 1903–04; by Samuel S. Gannett. Pp. 328 with map.

No. 247.—The Fairhaven Gold Placers, Seward Peninsula, Alaska; by FRED H. MOFFIT. Pp. 85, 14 plates, 2 figures.

No. 248.—A Gazetteer of Indian Territory; by HENRY GANNETT. Pp. 70.

No. 251.—The Gold Placers of the Fortymile, Birch creek and Fairbanks Region, Alaska; by LOUIS M. PRINDLE. Pp. 89, 16 plates.

No. 253.—Comparison of a Wet and Crucible-fire methods for the Assay of Gold Telluride Ores, with notes on the errors occurring in the operations of fire assay and parting; by W. F. HILLEBRAND and E. T. ALLEN. Pp. 30.

No. 254.—Report of Progress in the Geological Resurvey of the Cripple Creek District, Colorado; by WALDEMAR LINDGREN and FREDERICK LESLIE RANSOME. Pp. 34.—Besides the details of more purely economic importance it is noted that in the deeper workings much annoyance and even serious interference with work has been experienced from mine gases, often in spite of vigorous measures for ventilation. The analyses showed the gas to be a mixture of nitrogen with about 20 per cent carbon dioxide and a small amount of oxygen. The authors believe that it represents the last exhalations from the throat of the extinct Cripple Creek volcano.

No. 256.—Mineral Resources of the Elders Ridge Quadrangle, Pennsylvania; by RALPH W. STONE. 86 pp., 12 plates, 4 figures.

No. 257.—Geology and Paleontology of the Judith River Beds; by T. W. STANTON and J. B. HATCHER; with a chapter on the Fossil Plants; by F. H. KNOWLTON. Pp. 174, 19 plates.

No. 262.—Contributions to Mineralogy from the U. S. Geological Survey; by F. W. CLARKE, W. F. HILLEBRAND and others. Pp. 147, 12 text-figures.

No. 263.—Methods and Costs of Gravel and Placer Mining in Alaska; by CHESTER WELLS PURINGTON. Pp. 273, 42 plates, 49 figures.

No. 266.—Paleontology of the Malone Jurassic Formation of Texas; by F. W. CRAGIN; with stratigraphic notes on Malone Mountain and the surrounding region near Sierra Blanca, Texas; by T. W. STANTON. Pp. 172, 29 plates.

No. 267.—The Copper Deposits of Missouri; by H. F. BAIN and E. O. ULRICH. Pp. 52.

No. 271.—Bibliography and Index of North American Geology, Paleontology, Petrology and Mineralogy for the year 1904; by FRED BOUGHTON WEEKS. Pp. 218.

WATER SUPPLY and IRRIGATION PAPERS.—Nos. 97, 98, 99, 100, 103, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 124, 125, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 141, 143, 144, 146, 149.

2. *Osteology of Baptanodon* (Marsh); by C. W. GILMORE. Memoirs of the Carnegie Museum, Vol. II, No. 2, August, 1905. —Mr. Gilmore's excellent paper gives us for the first time a satisfactory discussion of the osteological structure of the Jurassic

Ichthyosauria of America. Notes by Marsh and Knight have acquainted us with the essential characters of the paddles, but little information concerning the remainder of the skeleton has been published, and investigators working on related groups have had no satisfactory basis for comparison with these important forms. The specimens studied by Mr. Gilmore include practically all of the known *Baptanodon* material. The figures presented represent the complete structure of the skull in all its aspects, the pectoral girdle, the anterior limb, and the anterior portion of the vertebral column. The posterior limb is not certainly known.

The characters of the dentition of *Baptanodon*, for the original discovery of which we are indebted to Mr. Gilmore, have been summed up in the statement that: "*Baptanodon* was well provided with comparatively small, somewhat slender but functional teeth that extended along the full length of the jaw; the most anterior ones being much reduced." In addition to the characters of the dentition, Mr. Gilmore notes specializations in the reduction of the cervical intercentra to a simple free element in *B. marshi*, the median fusion of the clavicles, and the presence of a sixth digit in the anterior limb.

In the comparison of *Baptanodon* with the European *Opthalmosaurus*, the two are shown to be remarkably similar. Distinguishing characters are found in the presence in *Baptanodon* of a sixth digit in the anterior limb, the uniform biconcave cupping of the anterior cervical centra, and the fusion of the clavicles. The two types are, however, very close together, as similar as one could reasonably expect to find species so widely separated geographically.

In the light of what is actually known, the relation of *Baptanodon* to the later Triassic forms of America seems still far from close. *Shastasaurus*, the youngest known Triassic genus, is at least in limb structure highly specialized along a line almost diametrically opposite that taken by *Baptanodon*. Unless a closer connection with the late Triassic forms of this continent can be discovered, we must continue to look upon *Baptanodon* as probably a Jurassic immigrant from the old world. The close relationship to the European *Opthalmosaurus* is additional evidence in favor of the suggestion that *Baptanodon* was a Jurassic importation. In this connection it is interesting to note that Frass* has recently described a vertebra which he believes to represent the genus *Opthalmosaurus*, from the Jurassic of Northeast Greenland. JOHN C. MERRIAM.

3. *Cambrian Faunas of India;* by CHARLES D. WALCOTT. Proc. U. S. National Museum, xxxix, 1905, pp. 1–106.—This paper is the result of a preliminary study of the Cambrian material collected by Mr. Blackwelder, as a member of the Carnegie Institution of Washington Expedition to China, under the leadership of Mr. Bailey Willis. Previous to this expedition, Kayser,

* E. Frass, Meddelelser om Grönland, xxix, p. 283.

Dames, and Bergeron had described 21 species, which are now increased by Walcott to 172 forms, of which 118 are trilobites. "The large fauna discovered in the reconnaissance made by Messrs. Willis and Blackwelder is an indication of the richness of the Cambrian faunas of eastern Asia, and of the great results that may be expected when systematic, thorough exploration and collecting are undertaken."

Almost the entire Cambrian seems to be represented here, and rests on the Tai Shan complex. The Lower Cambrian in the Man To formation has 12 species, and as the trilobite *Redlichia* is the diagnostic fossil, seemingly being a direct descendant of *Olenellus*, we are led to infer that the lower portion of the Lower Cambrian, as known in America, may be absent in China. The Middle Cambrian in the Chang Hsia formation is the richest in fossils. Another and higher member of this division is the Ku San shale, with a small fauna; followed by the Upper Cambrian in the Chao Mi Tien limestone, having another considerable faunal development.

"The fauna of the Ku San shale includes species of *Damesella*, *Dorypyge*, and genera that are typical of the Middle Cambrian fauna, while the fauna of the Chao Mi Tien limestone . . . . is more nearly related to that of the Upper Cambrian of North America and northwestern Europe."

Walcott's lists clearly indicate that the Middle Cambrian of China is directly connected with that of America, a fact long ago noted by Dames, and recently more decidedly by Frech. The Upper Cambrian also has the American impress, while the Lower Cambrian is Asiatic in character.

The oldest known cephalopod is described here as *Cyrtoceras cambria*. The structure, as described, is that of *Cyrtoceras*, but one would rather have looked for *Piloceras* or *Endoceras*-like forms in the Cambrian. Brachiopods, gastropods, and especially trilobites make up the faunas, while not a single bivalve is here recorded. Of new genera—all trilobites—there are *Dorypygella*, *Damesella*, *Anomocarella*, *Pagodia*, and *Shantungia*. C. S.

4. *The Cambrian Fauna of India;* by CHARLES D. WALCOTT. Proc. Washington Acad. Sci., vii, 1905, pp. 251–256. — The writer here reviews the small Cambrian fauna of India first described by Waagen; this has also been referred to the Silurian and Carboniferous. Walcott concludes: "In the absence of any fossils clearly indicating the Olenellus fauna I think it unwise at present to assume any other age for the fossiliferous Cambrian beds than Middle Cambrian." C. S.

5. *Catalogue of the Type Specimens of Fossil Invertebrates in the Department of Geology, U. S. National Museum;* by CHARLES SCHUCHERT, assisted by W. H. DALL, T. W. STANTON, and R. S. BASSLER. Bull. U. S. National Museum, No. 53, Part I, 1905, pp. i–v, 1–704.—This is an alphabetic catalogue of the type and illustrated fossil invertebrates in this museum, previous to 1905. It records 11,490 specimens of 6,100 species. Within

the past few years, three similar catalogues have been published. The first one, by the American Museum of Natural History, New York City; the second, by the New York State Museum, Albany, New York, and now the one cited above. The last, however, records the largest number of species, and is an indication of the great amount of paleontological work done at Washington.

6. *Graptolites of New York. Part I, Graptolites of the Lower Beds;* by R. RUEDEMANN. N. Y. State Mus., Mem. 7, 1904 (distributed March 1905), pp. 457–803, pls. 1–17.—This very valuable monograph had its origin in stratigraphic work by the author, in the slate belt of eastern New York. The book is of the greatest importance, not only to paleontologists and paleogeographers, but as well to the stratigrapher of the older Paleozoic formations. In fact, the work is so valuable that no review could bring out its many excellent points, unless it were of great length, for which space is not at our disposal. In this monograph are treated the late Cambrian and early Ordovician graptolites of America, the species and genera not only being described and illustrated, but also their structure, morphology, reproduction, development, mode of existence, phylogeny, and systematic position, as well as the bearing of these organisms on the stratigraphy and paleogeography of Ordovician time. C. S.

7. *Mesozoic Plants from Korea;* by H. YABE. Jour. College Sci., Imperial University, Tokyo, Japan, 1905, pp. 1–59, pls. i–iv.—Here are described 21 species, 3 of which are new. Filices are the most prevalent, being represented by 11 species.

"It is quite evident that the flora is Jurassic, for neither typically Rhaetic or Cretaceous forms are found in it."

"On the whole, so far as evidence goes, the writer has little hesitation in announcing the contemporaneity of the Naktong flora of Korea with that of the Japanese Tetori series [about Malm and Dogger], the affinity of the former to those of the corresponding age in Siberia, China, India and California being apparently more distant." C. S.

8. *Palaeontologia Universalis.*—Early in September of the present year, there appeared the first fascicle of the second series of this important publication. Ninety-four species are now redescribed and refigured and brought up to date. C. S.

9. *Ninth Annual Report of the Geological Commission, Dept. of Agriculture, Cape of Good Hope, for 1904.* Pp. 181 with numerous maps and figures. Cape Town, 1905.—This report contains the description of the detailed survey of several districts in the Colony of the Cape of Good Hope; thus adding valuable detail to the general works on South African geology which have recently appeared. J. B.

10. *Rock Cleavage;* by CHARLES KENNETH LEITH. Bulletin 239, U. S. Geol. Surv., 1905, pp. 216. 27 pls.—As noted by Dr. C. W. Hayes in the letter of transmittal, "The paper embodies the results of a very careful and laborious investigation of facts concerning rock cleavage and a discussion of their theoretical

significance. Its publication will place the subject of rock cleavage in a much more satisfactory shape and be of material assistance to all structural geologists." The writer divides secondary or induced cleavage into *flow-cleavage* and *fracture-cleavage*. The first is considered as depending upon a parallel arrangement of mineral particles and is shown to be developed by rock flowage, the cleavage, as held by Van Hise and Hoskins, developing at any instant normal to the greatest pressure, but the final direction of cleavage may be inclined to the direction of greatest pressure which has produced the deformation. Fracture-cleavage on the other hand is considered as not dependent upon a parallel arrangement of mineral constituents and as arising in a plane of shear in the outer zones of the earth's crust. The writer follows the inductive method of studying the facts in the field and laboratory and pointing out their significance. J. B.

11. *Experiments on Schistosity and Slaty Cleavage;* by GEORGE F. BECKER. Bulletin 241, U. S. Geol. Surv., 1904, pp. 34, 7 pls.—This bulletin embraces the results of valuable experiments upon clay and ceresin in a "scission engine" of the author's invention in order to test disputed theories of cleavage. The results show, according to Dr. Becker, that in these cases the cleavage arose on planes of shear and not in the planes subjected to greatest pressure. This is in conformity with the author's conclusions published ten years previously and these are regarded by him as establishing his contention that all cleavage is to be regarded as arising in planes of shear. As noted in the previous review, Professor Leith grants the occurrence of this form of cleavage, but regards it as only of partial application to the natural phenomena and distinct from the more common flow-cleavage. Leith also differs from Dr. Becker in the interpretation of the experiments, regarding the results as due to flow-cleavage. J. B.

12. *Die Alpen im Eiszeitalter;* von Dr. ALBRECHT PENCK, Professor an der Universität Wien und Dr. EDUARD BRÜCKNER, Professor an der Universität Bern. Part 6, pp. 545–656, 1904; Part 7, pp. 657–784. Leipzig, 1905.—These two parts continue the discussion of the Alps in the Glacial Period, and it is expected that the series will be completed upon the issuance of one more part. The volumes are well illustrated by profiles, maps, and photographs, and the names of the authors are a guarantee as to the quality of the work.

The subjects discussed in part 6 include the glacial history of the Reuss, Aar and Rhone valleys, the physiographic features and the nature of the interglacial plant remains. Part 7 deals chiefly with the French and southern Alps and discusses the paleolithic finds and their relation to the glacial and interglacial times. This work is of the utmost interest to anthropologists as well as to glacialists and physiographers and will rank for many years as a standard contribution to the Quaternary history of Central Europe. J. B.

13. *Structural and Field Geology;* by JAMES GEIKIE. Pp. xx + 435, 56 page plates, 142 text illustrations. New York, 1905 (D. Van Nostrand Co.).—This volume opens by describing the rock-making minerals, also the rocks and fossils in so far as they are related to structural geology. Following this are several chapters on the rock structures, such as stratification, faults, mode of occurrence of eruptive rocks and of ore formations. A third part deals with the principles of geological surveying and the economic aspects of geological structure. The work is made very attractive by clear typography, appropriate subdivisions, and by the number and excellence of the illustrations, taken almost entirely from the British Isles, the plates being photographic reproductions. In photographing the rock-types, however, there is a tendency to unnaturally heighten the color contrasts.

Within the limits indicated by the title this is an excellent treatise, the subject matter being well arranged and classified. The chief value is for its outdoor application, the student finding here a good discussion of field methods and a full description of the structures which he is to look for and identify. The subordination of the dynamical to the structural side results necessarily in the causal relations of earth structures and their interpretation from being made prominent. The ultimate significances of the geological facts are thus not well brought out, and as these are the highest significances they should not be lost sight of in geological instruction. However, as the volume does not profess to cover this side of the subject, it should not be urged as a criticism but should merely be called to the attention of educators as not supplying the whole of the inorganic side of the science. As a text-book presenting an excellent account of the facts and field methods upon which geological conclusions are based, it is of value to all students of pure or applied geology. J. B.

14. *The Clays and Clay Industries of Connecticut;* by GERALD FRANCIS LOUGHLIN. Bulletin No. 4 Connecticut Geol. and Natural History Survey. Hartford, Conn. 121 pp., 13 maps and plates. 1905.—This report gives first the geographical distribution of the Connecticut clays, followed by a discussion on the origin of clays in general and the geological history of the Connecticut clays in particular. It is shown that they were laid down in quiet waters fronting the continental glacier toward the close of the glacial period. The gravels, sands and clays give indications of water levels at 180, 120 and 80 feet above the present level of the sea. The writer ascribes the highest of these to damming by fragments of ice still lingering to the south, as the highest indication of shore lines to the south is only 120 feet above sea level. But in view of Fuller's recent paper on the Geology of Fisher's Island,* the reviewer suggests as not improbable that these high-level gravels and clays may mark a

* Bull. Geol. Soc. Amer., vol. xvi, pp. 367–390, 1905.

deepest stage of the Champlain submergence. If so they are of considerable scientific importance as serving to correlate the stages of ice retreat with the several stages of the Champlain subsidence within the New England states. Having given the geographical distribution and origin of the Connecticut clays, the subject is taken up of the chemistry of clays, the physical properties of clays and their commercial classification. Following this the composition, properties and adaptabilities of the Connecticut clays are given in detail. The lacustrine and estuarine clays, embracing the bulk of the clay deposits, while suited for the best quality of common red brick at low expense, are limited in their uses by high percentage of iron and extremely low fusing point. Part II treats of the clay industries of Connecticut.

The bulletin is well written throughout and is adapted to the comprehension of the intelligent but untechnical reader. The limited time and money appropriated for this work prevent it from being a final study of the subject, as noted in the introduction. Yet the results are of very considerable value, and by calling attention to one of the resources of the state which is, at present, but poorly developed, may ultimately yield a return in industry many times the comparatively small expenditure required for this report. J. B.

15. *Geology of Western Ore Deposits;* by ARTHUR LAKES, late Professor of Geology at the Colorado School of Mines. 438 pp., 300 illustrations. Denver, Col. (The Kendrick Book and Stationery Co.)—This volume is not written for the specialist but for the intelligent miner or other person interested in the subject of western ore deposits. Introductory chapters review the rock-making minerals, the ore minerals, and the features of structural and dynamical geology connected with ore deposits. A glossary and index serve a useful purpose. The principles of ore deposition and various types of ore deposits are treated, the examples being chiefly drawn from Colorado, with which state the writer is most familiar, but the mining districts of the other western states and of Alaska are also briefly reviewed, and the distinctive features indicated. J. B.

16. *The Delavan Lobe of the Lake Michigan Glacier of the Wisconsin Stage of Glaciation and Associated Phenomena;* by WILLIAM C. ALDEN. 106 pp., 15 plates. Washington, 1904. Professional Paper No. 34, U. S. G. S.—The author presents in this paper the detailed results of several seasons field work in the southeastern part of Wisconsin on a small tributary lobe of the Lake Michigan glacier. The points of chief interest lie in the proof, based on interlobate phenomena, of the contemporaneity of the Lake Michigan, Delavan, and Green Bay ice lobes and the simultaneous withdrawal of the two latter from their terminal moraines; and in the application to the deposits in this field of the criteria for the determination of the age relationships of the Wisconsin and pre-Wisconsin drift.

A large number of analyses of the drift of this region were made and its lithological character carefully determined therefrom. The interesting result is found that 87 per cent of the material is of local derivation, thus indicating a subglacial origin. The surface bowlders are predominantly foreign and therefore probably englacially transported. No essential lithological difference was noted between the drift of terminal moraines, outwash, ground moraines and drumlins. I. B.

17. *Platinum in Black Sands from Placer Mines*, DAVID T. DAY. —A circular sent out by U. S. Geological Survey in March, 1905, to some 8,000 placer miners, chiefly in the United States, has thus far brought in some 828 samples of black sands; these are largely from the western states and territories, but also from British Columbia, Central America and Mexico. Of these samples, 195 specimens were assayed for gold and platinum with the result of finding platinum in 72 of the specimens. Of these 72, 17 showed only a trace and 14 an amount equal to two ounces or more per ton of concentrate. A sample from Junction City mining district, Trinity Co., Cal., showed 25·8 oz.; one from Oroville, Butte Co., Cal., showed 27·45; and one from Riddle, Douglas Co., Oregon, 128·73 oz. In addition to these tests, 190 samples were examined as to the minerals present with interesting results; polycrase is noted in sands from Idaho Co., Idaho, and columbite and tantalite from Shoshone Co. Field work has also been carried on in the collection and examination of sands of various placer deposits, as also from bars in the Columbia river; important results may be anticipated from this thorough work.

18. CASSITERITE, *a new cleavage, or perhaps parting law;* by WILLIAM E. HIDDEN (communicated).—Preliminary announcement is hereby made of my late observation, at the Ross Tin Mine, near Gaffneys, S. C., of a new cleavage (or "parting") in cassiterite. This new cleavage is very common, almost perfect and is parallel to *e* (101, 1-$\bar{i}$). Very imperfect cleavages parallel to *s* (111, 1) and *m* (110, I) were also noticed, those with *s* being most common.

Measurements of $e \wedge \acute{e}$ (cleavage surfaces), with hand goniometer, gave 133½°, while the required angle is 133° 32′. Faces of the new cleavage up to four inches long and over two inches wide were noticed, remarkably smooth and flat. They are very characteristic of the locality. Twins parallel to the well-known twinning plane (*e*, 101) were not uncommon. Some of these were elongated with the *s* planes, making what seem to be prismatic planes, similar to sphene, etc. This new tin locality is already credited with having produced about forty tons of cassiterite (yielding over 70% metallic tin) and gives good promise for the future. The associated minerals are albite, microcline (?), amphibole, quartz, biotite, menaccanite, rutile, garnet and probably scapolite, monazite and eudialyte.

III. Miscellaneous Scientific Intelligence.

1. *Harvard College Observatory.*—Recent publications include the following:

Annals, Vol. LIII, No. V, Phoebe, the ninth Satellite of Saturn; by William H. Pickering.

No. VI, Investigation of the Orbit of Phœbe; by Frank E. Ross.

No. VII, Second Supplement to Catalogue of Variable Stars.

No. VIII, Martian Meteorology; by William H. Pickering.

No. IX, The ninth and tenth Satellites of Saturn; by William H. Pickering.

Vol. LVI, No. III. The Spectrum of Nova Persei, No. 2.

Circulars. No. 93, The 24-inch Reflecting Telescope.

No. 94, Variability of Eunomia (15).

No. 95, Brightness of Jupiter's Satellites.

No. 96, 843 new variable Stars in the small Magellanic Cloud.

No. 97, Bruce Photographs of Planets.

No. 98, Stars having peculiar Spectra.

No. 99, A probable new Star, RS Ophiuchi.

No. 100, Variable Stars in the Clusters Messier 3 and Messier 5.

No. 101, Positions of Ocllo (475) during 1904.

No. 102, Positions of Phoebe in May, 1904.

No. 103, Positions of Ocllo (475) during 1905.

No. 104, H 1174. A new Algol Variable, 035727.

2. *Publications of the Cincinnati Observatory.* No. 15, *Catalogue of 4280 Stars for the Epoch 1900;* by Jermain G. Porter, Director. 100 pp. Cincinnati, 1905 (University of Cincinnati).—The stars included in this volume are all those of Piazzi's catalogue which were north of the equator in 1800 except those contained in the Berlin Jahrbuch and eighteen of the Pleiades group; stars observed by Piazzi, but not given in his catalogue, are also included.

3. *Report of the Director of the Yerkes Observatary, University of Chicago;* by Professor George E. Hale. 1, for the period July 1, 1899 to June 30, 1902, pp. 32. 2, for the period July 1, 1902 to June 30, 1904, 8 pp.—These reports, though presented in very concise form, give a clear summary of the various lines of important work carried on at the Yerkes Observatory during the five years from 1899 to 1904.

4. *Carnegie Institution of Washington.*—Recent publications from the Carnegie Institution include the following:

No. 8. Bibliographical Index of North American Fungi; by William G. Farlow. Vol. I, Part I, Abrothallus to Badhamia, Pp. xxxv, 312, 8vo. Washington, Sept. 1, 1905.

No. 25, Evolution, Racial and Habitudinal; by Rev. John T. Gulick. Pp. xii, 269, 8vo. Washington, August, 1905.

No. 27. Bacteria in Relation to Plant Diseases; by Erwin F. Smith, in charge of Laboratory of Plant Pathology, Bureau of Plant Industry, U. S. Department of Agriculture. Volume I,

Methods of work and general literature of Bacteriology exclusive of Plant Diseases. Pp. xii, 285, 4to, with 31 plates and 146 text-figures. Washington, September, 1905.

5. *Annual Report of the Board of Regents of the Smithsonian Institution, showing the operations, expenditures and condition of the Institution for the year ending June 30, 1904.* Pp. lxxix, 804, with numerous plates and text-figures.—The advance report of the Secretary, Professor S. P. Langley, was noticed in the number for March, on page 261. The complete volume now issued contains this administrative report, occupying the first one hundred pages, and also following a general appendix, pp. 109–791, containing, as usual, a series of articles. These give brief accounts of important scientific discoveries, also reports of investigations made by the workers connected with the Institution, and some more extended papers on special subjects of interest to the correspondents of the Institution. The volume closes with biographical notices of Sir George G. Stokes, Professor von Zittel and Professor Karl Gegenbauer.

6. *Catalogue of the Collection of Birds' Eggs in the British Museum of Natural History.* Volume IV, *Carinatæ* (*Passeriformes* continued); by EUGENE W. OATES assisted by Capt. SAVILLE G. REID. Pp. xviii, 352, with 14 colored plates. London, 1905.—This fourth volume of the British Museum Catalogue of Birds' Eggs corresponds with the fourth volume of Dr. Bowlder Sharpe's Hand-list of Birds. The number of species included is 620, represented by 14,917 specimens.

7. *Bibliotheca Zoologica II. Verzeichniss der Schriften über Zoologie welche in den periodischen Werken enthalten und vom Jahre 1861–1880 selbständig erschienen sind;* bearbeitet von Dr. O. TASCHENBERG. Siebzehnte Lieferung.—The sixth volume of this comprehensive work is completed with the present part. Like the parts immediately preceding, it is devoted to the twenty-second section of the entire field, that of Paleozoology, which it brings to a close. The volume, title page, dedication, and table of contents are also included.

OBITUARY.

BARON FERDINAND VON RICHTHOFEN died on October 7th, at the age of seventy-two years.

PROFESSOR LEO ERRERA, Professor of Botany in the University of Brussels, died on August 1, at the age of forty-seven years.

Mr. G. B. BUCKTON, F.R.S., the English Entomologist, died on September 26, at the age of eighty-eight years.

M. ELISÉE RECLUS, the eminent French geographer, died in July last in his seventy-sixth year.

CRYSTALLOGRAPHY.

Our new Catalogue (xix) has just come out. Amongst others it gives brief descriptions of a number of new models, which have been constructed and used for teaching purposes at the Universities by Prof. Becke in Vienna, Prof. Groth in Munich, Prof. C. Hintze in Breslau, Prof. S. L. Penfield in New Haven, Prof. Vrba in Prag and others. The following are included:

1. *New Collection of 416 Crystal-models of wood*, containing all the crystal forms and combinations represented by illustrations in the new 4th ed. of the "Physikalische Kristallographie" by *Prof. Groth* (1905), - - - ca. M. 625.
2. *New Collection of 450 Crystal-models of paste-board*, systematically arranged according to the 32 classes of symmetry, by Prof. *K. Vrba*, - - - - - - - M. 960.
3. *The Planes of Symmetry*, 5 models constructed by Prof. *K. Vrba*, - - - - - - - - - M. 115.
4. *The Optical Wave surfaces*, 4 wire models, by Prof. *K. Vrba*, M. 128.
5. *The Optical Indicatrix*, 3 wire models, by Prof. *K. Vrba*, M. 45.
6. *The Sciodromes*, 5 plaster-models, by Prof. *F. Becke*.
7. *Stands for crystal-models*, various construction, and in various sets. See our new crystallographical catalogue, supplement to Catalogue Ib with numerous illustrations, post free on application.

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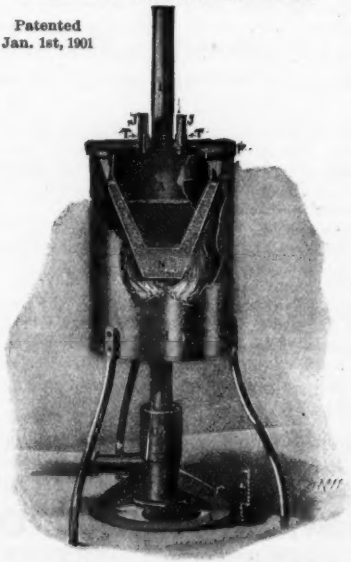

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